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ALASKA NATURAL GAS TRANSPORTATION SYSTEM

Final Environmental Impact Statement

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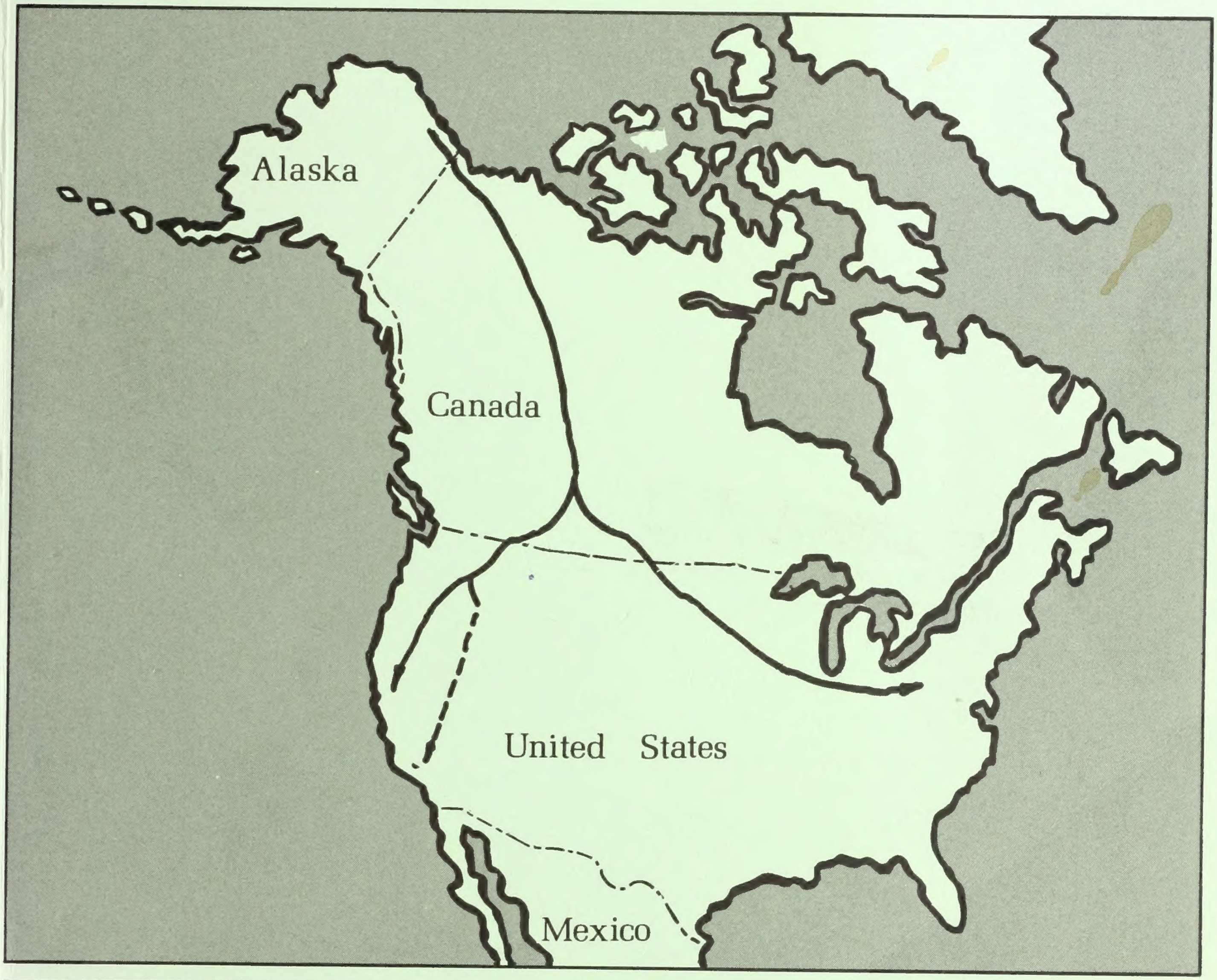

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ALASKA NATURAL GAS
TRANSPORTATION SYSTEM

Final Environmental Impact Statement

March 1976

This final Environmental Impact Statement has been prepared under the provisions of Section 102(2)(C) of the National Environmental Policy Act of 1969 (P.L. 91-190). Contact regarding the document should be addressed to:

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SUMMARY

( ) Draft   (x) Final Environmental Statement
United States Department of the Interior, Alaska Natural Gas Transportation System EIS Task Force

1. Type of action: (x) Administrative   ( ) Legislative

2. Brief description of action: Action pending is granting rights-of-way permits for crossing Federal lands. A 5,580-mile buried pipeline has been proposed to transport natural gas from Prudhoe Bay (Alaska) to markets in the lower United States. The pipeline, as proposed, would cross all, or portions of, Alaska; Yukon Territory, Northwest Territories, British Columbia, Alberta, and Saskatchewan (Canada); and Idaho, Washington, Oregon, California, Montana, North Dakota, South Dakota, Minnesota, Iowa, Illinois, Indiana, Ohio, West Virginia, and Pennsylvania. As proposed, all activities necessary for pipeline construction and operation will be phased over a seven-year period. Of all lands traversed by the proposal, 406 miles will involve lands under the jurisdiction of five Federal agencies, all of whom have permitting authority. Other permits or licenses also must be issued before construction may begin or the project becomes operational.

3. Environmental impact and adverse environmental effects: Because of the linear nature of the proposal, a wide spectrum of environmental impacts will occur if the pipeline is built. Impacts, which are detailed in the Overview and geographically-oriented volumes, will occur on climate, topography, geology, soils, water resources, vegetation, fish and wildlife, social and economic environments, land use and productivity, cultural resources, recreation and esthetics, and air quality (including noise). All impacts will not be adverse.

4. Alternatives considered: Alternatives covered include the courses of action open to the Secretary of the Interior to approve, deny, postpone, or accept and delay or deny part of the proposal; effects of gas deregulation and conservation; other natural gas sources; alternative energy sources and modes of transportation; and one major alternative transportation system involving an all-Alaska gas pipeline, liquefaction plants, and LNG tanker transport to the conterminous United States.

5. Comments have been received from the following: Comments were received from 23 Federal agencies, 35 State and local governments, Canada, 17 companies representing industry, 16 private organizations, 100 individual citizens, and three members of Congress. Comments from Federal agencies, State and local governments, Canada, private organizations, and members of Congress are reproduced in the Consultation and Coordination volume. Other comments will be reproduced and filed as a supplement to this statement at selected repository sites.

6. Date made available to CEQ and the public:

Draft statement: July 28, 1975
Final statement: MAR 1976

Note for Readers

This environmental impact statement was prepared in response to applications made to the Secretary of the Interior for permits to cross Federal lands with a natural gas pipeline. It identifies and evaluates environmental impacts that could be expected from construction and operation of the "Alaska Natural Gas Transportation System" as proposed by the consortium of companies listed in the Consultation and Coordination volume. It was prepared by an interdisciplinary team, most of whom are employees of the United States Department of the Interior.

Detailed construction designs and detailed plans for site restoration and system operation are not complete at this (proposal) stage of the project. For this reason, some of the impacts and mitigating measures are expressed in ranges of magnitude or qualified to reflect alternative situations.

The Secretary of the Interior considers a number of factors in reaching his decision regarding issuance or denial of right-of-way permits. The environmental impact analysis presented in this statement is an important but not necessarily the deciding factor. Alternative gas transportation systems proposals, United States-Canada diplomatic relations, national economic and risk analyses, national defense implications, energy efficiency analyses, and other factors must also be considered.

This statement is presented in nine volumes as follows:

Overview Volume
Alaska Volume
Canada Volume
San Francisco Volume
Los Angeles Volume

North Border Volume
Alternatives Volume
Consultation and
  Coordination Volume
Glossary Volume

Alaska, Canada, San Francisco, Los Angeles and North Border Volumes are geographically oriented. The Overview Volume, Alternatives Volume, and Consultation and Coordination Volume are not geographically oriented in their coverage.

The following subject groupings are covered sequentially in each of the geographically oriented volumes and Overview:

1. Description of the proposal.
2. Description of the environment.
3. The environmental impact of the proposed action.
4. Mitigating measures proposed and additional measures considered.
5. Adverse effects which cannot be avoided should the proposal be implemented.

6. The relationship between local short-term uses of (man's resources) and the maintenance and enhancement of long-term productivity.
7. Irreversible and irretrievable commitments of resources associated with the proposed action.
8. Alternatives to the proposed route.

The reader can review particular segments of the proposed project selectively. For example, a reader interested only in impacts on North Dakota, could use the Overview Volume for the system "big picture," and the North Border Volume for coverage of his particular State. Similarly, a person interested primarily in ways of transporting natural gas could refer to the Alternatives Volume and satisfy his needs.

Following is a brief description of the coverage of each part:

Overview Volume - The Overview covers the Arctic Gas System proposal in its entirety. It will be most useful to those readers who want a system view and a broad concept of anticipated environmental impacts of the entire pipeline project.

Alaska Volume - This volume covers the 195-mile proposal of the Alaskan Gas Arctic Pipeline Company originating at Prudhoe Bay and terminating at the Alaska-Yukon Border and alternative routes.

Canada Volume - This portion of the environmental impact statement analyzes the 2,435-mile pipeline proposal of Canadian Arctic Gas Pipeline, Ltd., beginning at the Yukon-Alaska Border and proceeding generally southward to Caroline Junction in Alberta where it forks, one leg entering Idaho, near Kingsgate, British Columbia, and the other entering Montana, near Monchy, Saskatchewan. Discussions of route alternatives are also presented.

San Francisco Volume - This volume analyzes the 917-mile portion proposed by the Pacific Gas Transmission Company which passes through Idaho, Washington, and Oregon to Antioch, California. Discussions of route alternatives are presented.

Los Angeles Volume - This volume relates to the 414-mile portion proposed by Interstate Transmission Associates (Arctic) extending from the point of United States entry in Idaho to Rye Valley, Oregon. It also involves modifications to existing compressor stations in Oregon, Idaho, and Colorado. Discussions of route alternatives are presented. This volume also contains a discussion of the applicant's future proposal for an additional 760-mile pipeline passing through Idaho, Oregon, Nevada, and terminating at Cajon, California.

North Border Volume - This volume is an analysis of the 1,619-mile pipeline proposed by the Northern Border Pipeline Company. It covers the area from the United States-Canada border, crossing Montana, North and South Dakota, Minnesota, Iowa, Illinois, Indiana, Ohio, and West Virginia, to a termination near Delmont, Pennsylvania. Discussions of route alternatives are presented.

Alternatives Volume - This volume covers courses of action open to the Secretary of the Interior to approve, deny, postpone, or accept and delay or deny part of the proposal; effects of gas deregulation and conservation; other natural gas sources; alternative energy sources and modes of transportation; and one major alternative gas transportation system involving an all-Alaska gas pipeline, liquefication plants and tanker transport to the conterminous United States.

Consultation and Coordination - This volume describes and discusses the efforts made by the Department of the Interior to consult with and coordinate its work in the development of this statement. It includes the gathering of basic information for analysis, public meetings, public hearings, and efforts which have and will be made to assure that environmental impacts are adequately treated.

Glossary - This volume provides the reader with definitions of technical words or phrases used in the environmental impact statement.

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8. Alternatives to the Proposed Action

8-A. Application for Rights-of-Way Across Federal Lands

The aim of the Alternatives volume of an environmental impact statement is to examine alternatives to the proposed action and to describe the environmental impact of those alternatives. In connection with the application for grants of rights-of-way across Federal lands during the construction of the proposed Alaska Natural Gas Transportation System, four options would be open to the Secretary of the Interior. The first would be to accept the application as submitted. The second would be to deny the application. The third would be to formally postpone decision on the application, facing decision at a later date. The fourth would be to accept the application on general terms but to consider the relative merits of permitting access as applied for with a selection of possible alternative routes.

Data on domestic and foreign natural gas resources, other alternative energy sources, and other alternative modes of transportation to handle the Alaska gas also are presented to document the possible choices within the total Federal capability. The alternative energy sources such as coal, petroleum, oil shale, and uranium, are discussed in terms of their ability to produce amounts of energy equivalent to that expected to be produced by the proposed pipeline. The alternative modes of transportation, such as dense-phase and methanol pipelines, LNG or methanol transportation by tanker or submarine, and the like, are compared to the Alaska Natural Gas Transportation System in terms of feasibility and efficiency, and their environmental impacts are described.

The Alaskan, Canadian, Northern Border, Los Angeles, and San Francisco segments of the Alaska Natural Gas Transportation System, as well as their possible internal and system-wide route alternatives, have been described in the corresponding geographic volumes of this environmental impact statement. The route alternatives are also aggregated for the total system and discussed in section 8.OV.3 of the Overview volume. The other major alternative transportation system for carrying the Alaska natural gas, a combination of an all-Alaska pipeline-LNG tanker-regasification system, is covered fully in section 8.2 of this Alternatives volume, while other modes are covered in section 8-F.

8-A-1. Accept Application

The option of accepting the proposed right-of-way application without consideration of other alternatives is essentially accepting the Applicant's proposal as described in the Overview volume in section 1.OV. Its impacts have already been examined and require no further discussion.

8-A-2. Deny Application

Inherent in the decision to produce oil at Prudhoe Bay was the realization that natural gas would also be produced. If the permit were denied, the environmental impacts of the action would not take place. The gas could be reinjected and not be taken from the reservoir for an indefinite period without adversely affecting the ultimate oil production. The denial of the application to transport natural gas from Alaska by a pipeline crossing Federal lands might mean that, at least for a limited time, no natural gas would leave the North Slope of Alaska.

It does not follow that the project would be stopped for perpetuity, for many long-range energy projects, such as the Passamaquoddy Bay tidal energy scheme in New Brunswick, Canada, are being reconsidered after some years of lying dormant, so, with this in mind, it could also happen at Prudhoe Bay. Revival of the proposal at a later period would amount to delaying the decision, however. Since decision to delay is described further below, it is not examined in detail here. Denial in some other context would probably result in one of the following.

Several speculative methods of transport of natural gas from the North Slope, other than by pipeline, have also been proposed by various people from time to time. It is technologically feasible to construct facilities on the North Slope of Alaska for liquefaction of natural gas or its conversion into methanol. After such modification it could be transported by ship or submarine, or possibly even by air. Proponents of water transport consider this method feasible, although it is apparent that the gas or its products could not move from the North Slope as rapidly as it might were the pipeline to be constructed.

Construction and maintenance of such LNG or methanol plants on the North Slope, over a long period, would cause more environmental impact in that area than pipeline construction and maintenance but would effectively preserve the entire area through which the pipeline would run from the impact of the right-of-way. Socio-economic impact on the North Slope would probably be severe, but, with construction of the transport vessels (tankers and submarines) taking place elsewhere, might have less impact locally in the long run than would the construction of the pipeline. These types of systems and alternatives are described in later sections of this volume.

Because denial of the application would delay movement of the gas as a result of the use of slower alternative modes of transportation, it might also hasten the adoption of the use of substitute energy sources and conservation measures. Concern about the effects of a possible gas shortage would probably be balanced against the potentially greater environmental impact of possible future precipitous action to alleviate such a shortage.

Alaskan and Canadian Segments

Denial of the application to construct either the Alaskan or Canadian segment or both segments of the proposed Alaska Natural Gas Transportation System across Federal lands would essentially mean denial in its entirety. In the event of denial, the following options would be open to the Applicant:

1) The companies could reinject the natural gas that is produced with the oil at the Prudhoe Bay field without adversely affecting the ultimate oil recovery.

2) The gas could be converted to a liquid form (methanol or liquified natural gas, known as LNG) at the North Slope and stored there for future use or shipment. This would entail the construction of conversion facilities and storage tanks on the North Slope.

3) The gas could be transported to market areas by some other route or mode of transportation not involving rights-of-way across Federal lands. Possible alternative routes are described in the five geographic volumes of this environmental impact statement and in section 8.OV.3 of the Overview volume. Other possible alternative modes of transportation are described in sections 8-F and 8.2 of this Alternatives volume.

Under the first two options, energy supplies would not be made available to markets in the conterminous United States within the proposed time frame whereby initial deliveries are expected to begin in 1979 and deliveries at full capacity in 1982. Because shortages in U.S. natural gas supplies are anticipated during that period, elimination of this shortfall would require accelerated development of the potential alternative energy sources that are expected to replace dwindling gas supplies in the future. In either of these options, gas from the Prudhoe Bay field would be available for use in the future. Likewise, conversion of gas to liquid form or to methanol would decrease the amount of energy that would be available.

If the Alaskan gas were not transported to U.S. markets, the result could be one of the following conditions or combinations thereof: 1) development of an alternative energy source or combination of sources could be accelerated to replace the energy supply of the gas that would have been transported; 2) policies such as additional administered or regulated conservation measures could be enacted to decrease energy use; or 3) the markets that would have been served by the system would be denied the energy which would have been made available by the system.

Northern Border Segment

Denial of the application to build the proposed Northern Border pipeline project across Federal lands would increase deficiencies in projected gas supplies for areas served by the Northern Border Companies and would affect the ability of the companies to supply natural gas to their customers along the proposed route in Montana, North Dakota, South Dakota, Minnesota, Iowa, Illinois, Indiana, Ohio, and Pennsylvania.

Should the project not be constructed these Northern Border Companies would be required to:

1) Consider other routes or systems for transporting Alaska gas.

2) Seek natural gas supplies elsewhere.

3) Replace natural gas energy with other types of fuel.

4) Curtail supplies to customers.

5) Promote conservation programs.

Impacts--If the proposed pipeline is not built, the impacts on the environment resulting from construction and maintenance of the pipeline will not occur. Other impacts would occur and their nature would depend upon which of the five options above was followed. If other routes or systems were chosen to deliver the Alaska gas to the Northern Border market area, the impacts would be in the area of the alternative routes or systems. These are described in detail in the Northern Border volume.

The availability of other natural gas supplies depends on the supply and demand situation for gas in the Northern Border area. If the energy supplies are not made available by one of the first three options, gas supplies will be curtailed based on projected supply and demand for the region, following the Federal Power Commission's pattern of curtailment (FPC, 1975b, p. 208-209).

The impacts of curtailment would be largely the creation of socioeconomic problems as service is curtailed first for interruptible requirements, then for larger industrial requirements, and finally for smaller commercial and residential requirements. Impacts would include possible plant shutdowns and layoffs with resulting socio-economic problems in the market area of the Northern Border Companies. The actual effects would depend on what measures were taken by customers to compensate for curtailments. This could cause significant population migration to other areas with resultant environmental impact.

San Francisco Segment

Denial of the application to build the proposed San Francisco pipeline, extending from Kingsgate, British Columbia to Antioch, California, and crossing Federal lands, would require the Pacific Gas and Electric Company to:

1) Consider other routes or systems to transport Alaska gas.

2) Seek natural gas supplies elsewhere.

3) Replace natural gas energy with other types of fuel.

4) Initiate curtailments to its customers.

5) Promote conservation programs.

Impacts--If permission is denied, the impacts to the environment which would result from construction and maintenance of the pipeline, as described in the San Francisco pipeline volume, would not occur. Other impacts would occur and their nature would depend upon which of the five options above was followed. If other routes or another transportation system delivered the Alaska gas to the San Francisco area, the impacts resulting would be related to the route chosen for the transportation and are discussed in detail in the San Francisco pipeline volume. Alternative modes of transportation including a combination all-Alaska pipeline-LNG tanker system from Alaska to west coast port sites, are discussed and their impacts analyzed in sections 8-F and 8.2 of this Alternatives volume.

The availability of other natural gas supplies to the San Francisco area would depend on the supply and demand situation both nationally and for the region. If the energy supplies are not made available by one of the first three options, it can be predicted that gas supplies would be curtailed on the basis of projected supplies and demand for the region, according to the Federal Power Commission's pattern of curtailment. The impacts of curtailment would be similar to those discussed for the Northern Border area and could include plant shutdowns and layoffs with resulting socio-economic problems in the San Francisco market areas.

Los Angeles Segment

Denial of the application for the proposed Los Angeles pipeline across Federal lands and extending from Kingsgate, British Columbia to Rye Valley, Oregon according to the latest amendment and to be extended in the future to Cajon, California, would require the Interstate Transmission Associates (Arctic) to take essentially the same steps and would have the same effects as those described for the Northern Border and San Francisco pipelines, except that the areas primarily affected would be the Los Angeles and southern Oregon service areas. If other routes were used or another transportation system delivered the Alaska gas to the Los Angeles area, the impacts resulting would be related to the routes chosen for the transportation. The impacts of these alternative routes are discussed in detail in the Los Angeles pipeline volume. Alternative modes of transportation including a combination all-Alaska pipeline-LNG tanker-regasification system from Alaska to west coast port sites, are discussed and their impacts analyzed in sections 8-F and 8.2 of this Alternatives volume.

8-A-3. Postpone Decision on Application

Although this approach would lead sooner or later to acceptance or rejection, it is an important option and would be judged seriously. Any present decision to defer should include the expectation of an early decision either to proceed with or abandon the proposed project. For purposes of discussion, one may assume that a decision to postpone would be reconsidered in one to five years. Oil production is anticipated by mid-1977 from Prudhoe Bay. For two to three years oil production can easily be accompanied by reinjection of the gas. Reinjection might mean some irretrievable loss of gas needed to power compressors, although it likely would be no more than a few percent of the total available amount of gas.

Impacts

Both positive and negative environmental impacts would occur during this period. Of necessity, discussion of them must be speculative. One negative feature is that, if construction is postponed, the cost of the pipeline would certainly be higher because of inflation and related economic conditions. This factor carries with it many socio-economic impacts. To offset this in part, the time would allow for more detailed planning of the route, setting up a more efficient and less expensive construction schedule, and furnish an opportunity to evaluate the engineering experience gained on the TAPS pipeline project. It would also give the domestic economy of Alaska time to recover from the impact of the vast sums being poured into TAPS and the attendant boomtown and hyperurbanization conditions which have resulted from it (Griffith, 1975). If these additional human costs could be counted, it might be that a delay in construction would not significantly increase the estimated original cost. Experience gained in operation and maintenance of the TAPS pipeline project would certainly be applicable to the Alaska Natural Gas Transportation System and likely would result in money-saving innovations.

A delay certainly might mean an increase in the cost of natural gas if the decision were then made to proceed. On the other hand, one of the aims of a national energy policy should be to decrease our dependence on fuels which are in short supply by moving the economy toward fuels which are in greater supply, especially coal. To design new industrial, commercial, and residential structures for the use of fuels other than natural gas might increase their original cost. If it were apparent that it was a national policy to restrict natural gas and keep new sources off the market for some time, this would give an impetus to building design and construction for other fuels. The result would probably be an economic incentive toward design which would incorporate use of solar energy.

Another positive feature of decision to delay is that this would reinforce in the most forceful way a national commitment toward conservation of energy giving a strong boost to efforts at conservation, which currently are lagging. Of necessity, household thermostats would be set at a lower temperature and industries would have to be more economical in their use of natural gas, by converting to another fuel whenever possible. Growth in use of natural gas is projected by the applicants for the residential, commercial, and industrial sectors, apparently based on the premise of business as usual. Because the supply of natural gas is limited, no matter where it may be obtained, a decision to delay would lead to conservation, as the number of new hook-ups in the immediate future would be decreased dramatically and some large users might be persuaded to switch to other fuel sources. Both actions would insure that inelastic demand for natural gas could be met for a longer time in the future. Delay clearly stated as a conservation effort would indicate that it was a forceful program which would be implemented by drastic means if necessary.

It is becoming increasingly apparent that conventional thinking of natural resources as inexhaustible is now moving to the more realistic view that natural gas and other minerals are both finite and unequally distributed on the earth's surface. The natural gas from the Arctic might assist the nation's current energy problems for several decades, but once it is used up, there is no more. Many persons who have considered this issue would tend to agree that so long as it is economically feasible, it is better either to practice conservation of the finite natural gas resources by moving more quickly to the use of the more abundant fossil fuels or other energy sources, or to import resources and husband those of the nation for the future.

The technology of importation of Liquified Natural Gas (LNG) is developing rapidly, after a number of years of operation and experimentation on a small scale. If no gas transportation system were built in Alaska alone or in both Alaska and Canada to carry the Arctic gas, the presence in the conterminous United States of approximately five large LNG receiving terminals, serviced by an LNG tanker about every two days, could insure delivery to the conterminous United States of at least as much natural gas as might be expected from the Alaska Natural Gas Transportation System. Any such construction would be in addition to facilities already being built or proposed. Although no detailed calculations have been made, it would appear that the necessary plants and tanker fleet could be procured at about the same cost and within about the same time frame as the pipeline (CAGPL, 1974; FPC, 1975b; U.S. Dept. Commerce, Maritime Administration, 1975). Because LNG technology on a large scale is new, costs to the consumer are difficult to estimate. If a reliable overseas source could be assured, delay of the pipeline would give major impetus to LNG imports and would cause significantly less domestic socio-economic and environmental impact than its immediate construction.

The virtue of delay must be balanced against the difficulties it might cause. There is inadequate natural gas to supply the needs of all residential, commercial, and industrial customers who desire to use this fuel. There is a current shortage, but it is by no means clear how widespread, how urgent, and how serious this shortage really is. The House of Representatives, Committee on Government Operations (1975) and the Office of Management and Budget have reached quite different opinions as to the degree of severity of the shortage. There are also charges in the public press that some of the shortage at the current time is manufactured by the deliberate withholding of gas from the market. With this current difference of opinion there may be merit in delay to determine if the need for the pipeline is as urgent as it has been assumed in some quarters.

There is a tendency to judge that a decision to produce the oil in Prudhoe Bay automatically carried with it a decision to produce the associated gas forthwith. Prudent reservoir engineering practices indicate that, at least for several years, reinjection of the gas will not adversely affect the oil supply. Thus, for such a short period, there would be no harm done to the oil or natural gas supply associated with any decision to defer pipeline construction.

An interesting facet of this subject is raised in the U.S. Department of the Interior's Title III Study Team's draft report (1975), in which it is indicated that production of gas will require a significant addition of funds for drilling in the Prudhoe Bay area beyond that to be expended for oil production. Further, there is the possibility that production of natural gas might lead to a net loss in the oil production anticipated from Prudhoe Bay. The arguments are based mainly on economics and not on reservoir characteristics. If this were so, the socio-economic impact associated with the addition of natural gas to the supply in the conterminous United States would have to be balanced against the impact of loss of energy from lower than expected oil production.

A short delay would insure that more details could be obtained about reservoir characteristics, thus allowing a more sound decision to be made as to whether the Alaska Natural Gas Transportation System should be built or whether alternative modes of transportation should be used instead.

8-A-4. Accept Part of the Application and Deny or Delay Part

Acceptance of part of the Alaska Natural Gas Transportation System does not mean automatic acceptance of the precise route proposed. Rather it could be considered acceptance of the concept of a need for the pipeline with routing. For the proposed action, acceptance of a route through the appropriate portions of Alaska and Canada is the key, for without the Alaska-Canada segment of the project, the Alaska Natural Gas Transportation System would be a non-entity. For purposes of discussion, one may assume that this part of the pipeline along some route will be granted.

The question of the use of the remainder of the pipeline system must be considered. If the sole purpose is to convey natural gas from the Arctic regions, the environmental impact of the pipeline construction alone can be considered. The pipeline impinges on areas about which there has been extended discussion of construction of Synthetic Natural Gas (SNG) plants. If the pipeline were built with excess capacity so that eventually SNG could be fed into it, such data must be clearly stated, for the impact of the pipeline would then be significantly more than that of simple construction. It would include the environmental impact of coal mining and the production and enrichment of SNG to equal the quality of the natural gas of the Alaska Natural Gas Transportation System, as a consequence of the market outlet given by the pipeline.

For purposes of discussion, it will be assumed that unenriched SNG is not a consideration in the routes chosen for these pipelines. It should be noted that one of the stipulations in the agreements and grants of right-of-way with the United States and the State of Alaska for the Trans-Alaska Pipeline (TAPS) prevents the use of this pipeline for any product except oil, without the express written permission of the Secretary of the Interior and the Commissioner of the Alaska Department of Natural Resources. Presumably if the aim of the proposed project were to transport natural gas only and if the application for construction were granted, a similar stipulation could be prepared limiting the pipeline to natural gas, which could include SNG enriched to natural gas quality.

The proposal states that the gas pipeline in southern Canada would divide with one branch (Los Angeles and San Francisco segments) serving predominantly the Pacific Slope and the other branch (Northern Border) serving the northern midwest and northeast. It was presumed that the

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combined west coast pipelines would have the capacity to deliver 876 Bcf/yr and the Northern Border, 2153.5 Bcf/yr.

If the need for an Alaska Natural Gas Transportation System is recognized, there is a strong basis for seriously considering both partial acceptance and partial denial or delay. This form of decision has the greatest flexibility and might better conform to other aspects of a national energy plan.

Decision to delay or deny part of the project would save certain areas from the impact of construction. It would also save between one-quarter and one-third of the natural resources which must be irrevocably committed to the pipeline and would allow for greater speed in constructing the authorized part because of greater availability of trained manpower.

Other energy sources which might in part be substituted for the Arctic natural gas must be taken into consideration. Although they are treated in general terms in subsequent sections, attention should be directed here to the geographic location of the areas where increase of conventional or novel energy resources might be expected. It is evident that most potential areas for expansion of geothermal and hydroelectric energy are in the western part of the United States. Coal resources are more scattered, but again the most promising ones for future development are in the western United States. One environmental impact is associated with production from an energy source and a second is associated with transporting it to market. Because of the relationship of these new potential sources to population centers, it is apparent that there would be less environmental impact associated with transporting increased amounts of coal, geothermal energy, and hydroelectric power toward the west coast than there would in transporting the same amount toward the east coast.

Acceptance of part of the system in the conterminous United States need not be construed as an automatic denial of the remainder, for a decision to defer would allow part of the pipeline to be considered at a later time. Building one major part in the conterminous United States and deferring the other would have an effect on the gas supply available to one market area. The relative need for or the storage of natural gas in a market area depends in part on the current supply situation and in part on projections of future needs. A detailed study of the market areas to be reached by the Northern Border and west coast segments is difficult to make although some generalizations may be stated. As far as natural and physical systems are concerned, delivery of natural gas for expansion of human population and increased industrial output would have a greater adverse environmental impact than delivery of gas to maintain the current level of development.

On the west coast, the pipeline system consists of two legs which have a total length of about 1300 miles of pipeline. Details of the proposed and alternative routes are given in the Los Angeles and San Francisco volumes of this statement. It is still anticipated that these combined segments would be able to deliver 876 Bcf/yr. The Northern Border route is about 1600 miles long, some 20 percent longer than those on the west coast. This segment would still be able to deliver about 2153.5 Bcf/yr. Regardless of the merits of either system in terms of environmental impact, the available data indicate that either the two west coast segments or the Northern Border segment alone could use more than the 820 Bcf/yr, of which there is reasonable assurance of delivery from Prudhoe Bay.

Yet another set of problems arises if only part of one or both segments is authorized and these segments are then connected to already existing pipelines. There is the movement of gas by "displacement." The environmental impact of construction would not be present, but there would be complex socio-economic impacts.

As with the decision to deny permits or delay construction, this action would direct public attention to the use of alternative fuels other than natural gas. It would also be a spur toward conservation. In both these areas of concern, however, the effect would be less precipitous and less of a socio-economic impact than would that of the other two courses of action.

8-A-5. Energy Conservation

One possible alternative to denial or delay of applications for delivery of Alaska gas is conservation of equivalent amounts of energy through administered, regulated, or voluntary conservation programs (Bethe, 1976). From the standpoint of environmental impact on natural systems, the less energy used by man the better, but it is equally clear that an abrupt decline in the current use of energy or even a dramatic change in the growth rate will have profound socio-economic effects on present standards of living.

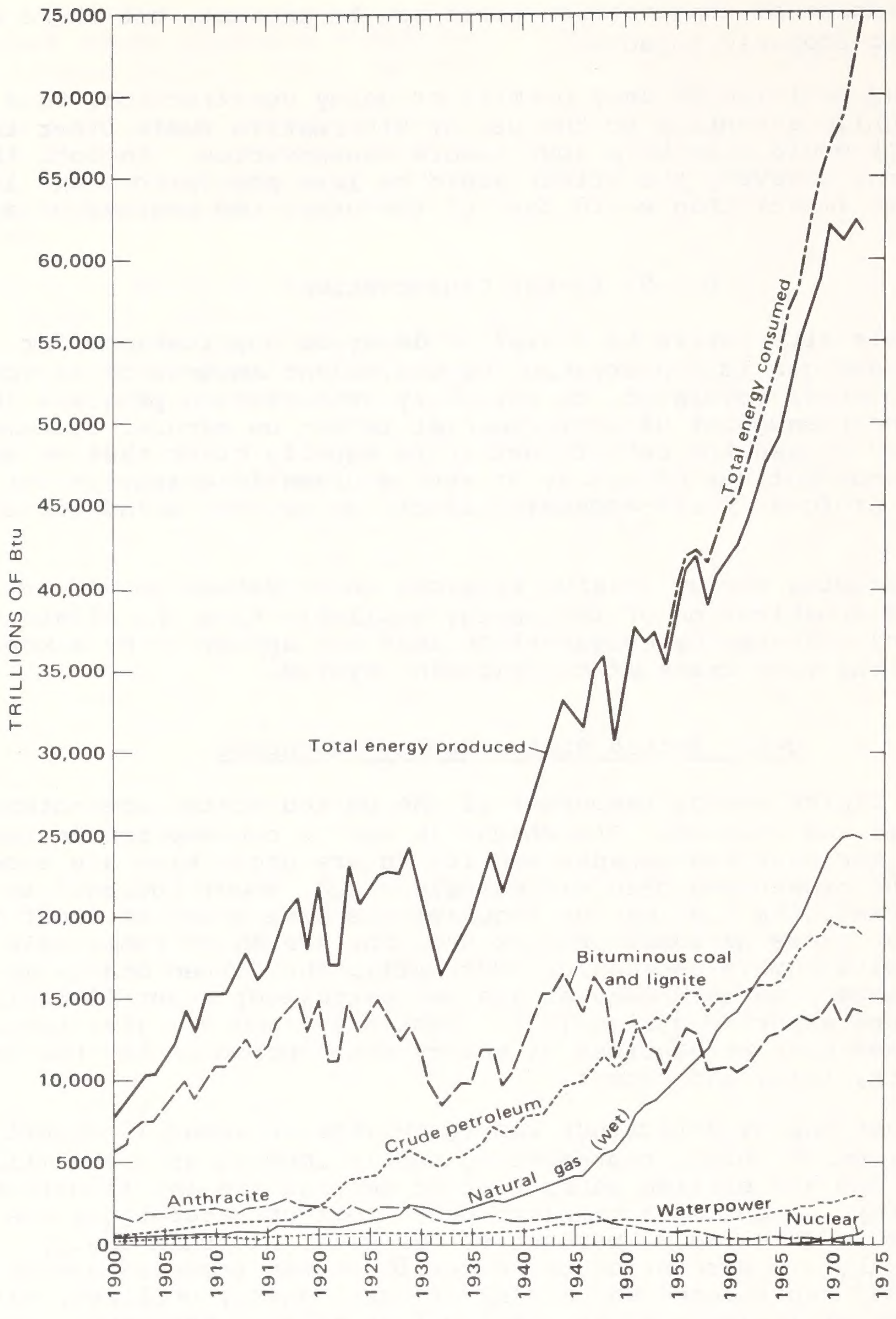
With the growing energy crisis, vigorous conservation should be instituted, but substitution of the energy available from the Alaska Natural Gas Transportation System by conservation does not appear to be a realistic alternative in the time frame of the pipeline system.

8-B. United States Energy Resources

The major finite energy resources of the United States are natural gas, coal, petroleum, and uranium. The change in energy consumption in this country during the past few decades and its future projection are shown in Figure 8-1. The growth has been exceedingly rapid, about fourfold in thirty years. In general, the U.S. energy requirements have grown at about the same rate as our gross national product and, for the short term, this growth rate probably will remain unchanged. Currently, the United States is energy deficient in respect to both natural gas and petroleum; about 52 million tons of coal were exported during 1973. Tables 8-1 and 8-2 give historical, current, and Base Case projections of energy consumption in the United States by source, form, and sector.

In 1973, net energy deficiency was equivalent to about 12 quadrillion British thermal units (Btu), representing mainly imports of 2,158 million barrels of oil and 950 billion cubic feet of natural gas and liquified natural gas (LNG). About 22.1 trillion cubic feet of natural gas was consumed in 1973. This was 31 percent of the total national energy utilization. Only 2.5 percent of the natural gas was imported gas or LNG. Petroleum in 1973 represented 46 percent of total energy utilized, with about 36 percent of it imported as crude oil or refined products. Coal consumption in 1973 was 18 percent of total energy utilized, with about 8 percent of domestic coal production exported. Nuclear power in 1973 was less than 2 percent and hydroelectric power about 4 percent of total energy supply. During the year, total consumption of energy in the nation was equivalent to 75.6 quadrillion Btu.

The Base Case projections of energy consumption to the year 1990 provide a quantified base for analysis of various alternatives to the proposal for delivery of Alaska gas to the Lower 48 States (FPC, 1975b). The assumptions for Base Case II are for a "conservative realistic situation" to the year 1990, which includes completion of a pipeline from the Alaska North Slope that will market Alaskan gas in the Lower 48 States.



Source: Averitt, Paul, U.S. Geological Survey Bulletin 1412, 1975, Figure 11

Figure 8-1 Annual production and consumption of energy in the United States, 1900-1973

Table 8-1 Consumption of energy in the United States by major commercial sources, forms, and consuming sectors (conventional units)

	Coal million short tons	Gas, dry billion cubic feet	Petroleum and natural gas liquids million barrels	Uranium U_3O_8 thousand short tons	Hydropower million kwh	Total Electricity generation million kwh	Total Electricity distribution by sectors million kwh
Residential							
1962	–	3,467	425	–	–	–	231,962
1971	–	5,059	558	–	–	–	499,615
1972	–	5,263	484	–	–	–	506,724
1973	–	5,510	506	–	–	–	536,285
1975	–	5,100	592	–	–	–	628,371
1980	–	5,039	658	–	–	–	838,000
1985	–	5,262	750	–	–	–	1,137,384
1990	–	5,216	812	–	–	–	1,540,000
Commercial							
1962	33	1,218	362	–	–	–	152,665
1971	15	2,066	592	–	–	–	328,901
1972	12	2,150	514	–	–	–	333,739
1973	11	2,250	538	–	–	–	353,209
1975	12	2,276	629	–	–	–	421,539
1980	11	2,470	698	–	–	–	577,000
1985	4	2,707	796	–	–	–	809,271
1990	2	2,898	862	–	–	–	1,138,000
Industrial							
1962	170	6,579	800	–	–	–	358,998
1971	164	10,125	982	–	–	–	589,728
1972	155	9,618	596	–	–	–	599,331
1973	160	9,800	641	–	–	–	634,296
1975	169	11,819	1,186	–	–	–	860,283
1980	175	11,806	1,382	–	–	–	1,384,000
1985	190	11,816	1,663	–	–	–	1,869,590
1990	207	11,643	1,947	–	–	–	2,536,000
Transportation							
1962	–	182	2,051	–	–	–	5,000
1971	–	800	3,005	–	–	–	4,537
1972	–	766	3,187	–	–	–	5,242
1973	–	790	3,308	–	–	–	5,548
1975	–	989	3,360	–	–	–	6,000
1980	–	1,408	3,992	–	–	–	7,000
1985	–	1,619	4,739	–	–	–	7,000
1990	–	1,663	5,518	–	–	–	8,000
Other and Unaccounted For							
1962	–	–	66	–	–	–	195,932
1971	–	–	–	–	–	–	297,989
1972	–	–	27	–	–	–	302,287
1973	–	–	29	–	–	–	319,922
1975	–	–	–	–	–	–	386,807
1980	–	–	–	–	–	–	486,000
1985	–	–	–	–	–	–	778,755
1990	–	–	–	–	–	–	1,322,000

Table 8-1 (cont.)

	Coal million short tons	Gas, dry billion cubic feet	Petroleum and natural gas liquids million barrels	Uranium U_3O_8 thousand short tons	Hydropower million kwh	Total Electricity generation million kwh	Total Electricity distribution by sectors million kwh
Electricity							
1962	193	1,966	92	.1	168,283	944,557	
1971	328	3,993	396	2.1	267,136	1,720,770	
1972	351	3,979	494	3.1	272,700	1,747,323	
1973	388	3,600	557	4.6	271,100	1,849,260	
1975	425	4,110	565	20.0	278,000	2,303,000	
1980	500	3,977	640	40.0	292,000	3,292,000	
1985	600	3,896	725	73.0	305,000	4,602,000	
1990	700	3,780	800	123.0	319,000	6,544,000	
Total Energy Inputs							
1962	397	13,612	3,796	.1	168,283	944,557	
1971	507	22,043	5,533	2.1	267,136	1,720,770	
1972	518	21,776	5,302	3.1	272,700	1,747,323	
1973	559	21,950	5,579	4.6	271,100	1,849,260	
1975	606	24,294	6,332	20.0	278,000	2,303,000	
1980	686	24,700	7,370	40.0	292,000	3,292,000	
1985	794	25,300	8,673	73.0	305,000	4,602,000	
1990	909	25,200	9,939	123.0	319,000	6,544,000	

Source: FPC, 1975b, National Gas Survey, Vol. I, Chap. 6, Tables 6-10

Prepared by: Office of Economics, Federal Power Commission

Table 8-2 Consumption of energy in the United States by major commercial sources, forms, and consuming sectors (energy equivalent units)

	Coal	Dry Gas	Petroleum and natural gas liquids	Uranium[1] U_3O_8	Hydropower[2]	Total gross energy[3] resources inputs	Total electricity[4] generation	Total electricity[4] distribution by sectors	Total primary & secondary energy inputs to sectors
Residential									
1962	–	3,578	2,807	–	–	6,385	–	792	7,177
1971	–	5,221	3,175	–	–	8,396	–	1,705	10,101
1972	–	5,426	3,233	–	–	8,659	–	1,728	10,387
1973	–	5,681	3,407	–	–	9,088	–	1,829	10,917
1975	–	5,263	3,371	–	–	8,634	–	2,144	10,778
1980	–	5,200	3,744	–	–	8,944	–	2,859	11,803
1985	–	5,430	4,268	–	–	9,698	–	3,881	13,579
1990	–	5,383	4,622	–	–	10,005	–	5,255	15,260
Commercial									
1962	906	1,257	2,422	–	–	4,585	–	521	5,106
1971	390	2,132	3,370	–	–	5,892	–	1,122	7,014
1972	387	2,216	3,434	–	–	6,037	–	1,138	7,175
1973	370	2,320	3,617	–	–	6,307	–	1,204	7,511
1975	325	2,349	3,579	–	–	6,253	–	1,438	7,691
1980	300	2,549	3,976	–	–	6,825	–	1,969	8,794
1985	100	2,794	4,532	–	–	7,426	–	2,761	10,187
1990	50	2,991	4,908	–	–	7,949	–	3,883	11,832
Industrial									
1962	4,627	6,789	4,683	–	–	16,099	–	1,225	17,324
1971	4,465	10,449	5,391	–	–	20,305	–	2,012	22,317
1972	4,267	10,591	5,668	–	35	20,561	–	2,013	22,604
1973	4,454	10,825	6,043	–	35	21,357	–	2,163	23,520
1975	4,600	12,136	6,510	–	–	23,246	–	2,935	26,181
1980	4,750	12,184	7,590	–	–	24,524	–	4,722	29,246
1985	5,150	12,194	9,130	–	–	26,474	–	6,379	32,853
1990	5,630	12,015	10,689	–	–	28,334	–	8,653	36,987
Transportation									
1962	18	394	11,000	–	–	11,412	–	17	11,429
1971	7	825	16,139	–	–	16,971	–	16	16,987
1972	4	790	17,264	–	–	18,058	–	18	18,076
1973	5	814	17,927	–	–	18,746	–	19	18,765
1975	–	1,020	18,050	–	–	19,070	–	21	19,091
1980	–	1,453	21,440	–	–	22,893	–	24	22,917
1985	–	1,671	25,450	–	–	27,121	–	24	27,145
1990	–	1,716	29,632	–	–	31,348	–	27	31,375

Table 8-2 (cont.)

	Coal	Dry Gas	Petroleum and natural gas liquids	Uranium[1] U_3O_8	Hydropower[2]	Total gross energy[3] resources inputs	Total electricity[4] generation	Total electricity[4] distribution by sectors	Total primary & secondary energy inputs to sectors
Other and unaccounted for									
1962	–	–	580	–	–	580	–	668	1,248
1971	–	–	–	–	–	–	–	1,016	1,016
1972	–	–	233	–	–	233	–	1,031	1,264
1973	–	–	260	–	–	260	–	1,091	1,351
1975	–	–	–	–	–	–	–	1,320	1,320
1980	–	–	–	–	–	–	–	1,658	1,658
1985	–	–	–	–	–	–	–	2,657	2,657
1990	–	–	–	–	–	–	–	4,510	4,510
	–	–	–	–	–	–	–	4,937	4,937
Electricity									
1962	4,638	2,029	579	22	1,777	9,047	3,223	(3,223)	–
1971	7,607	4,121	2,490	388	2,799	17,408	5,871	(5,871)	–
1972	7,880	4,102	3,074	576	2,831	13,463	5,958	(5,958)	–
1973	8,711	3,711	3,466	853	2,814	19,555	6,306	(6,306)	–
1975	9,860	4,241	3,552	3,588	2,780	24,021	7,858	(7,858)	–
1980	11,600	4,104	4,024	9,492	2,847	32,067	11,232	(11,232)	–
1985	13,920	4,021	4,558	19,229	2,928	44,656	15,702	(15,702)	–
1990	16,240	3,901	5,029	34,696	3,031	62,897	22,328	(22,328)	–
Total energy inputs									
1962	10,189	14,047	22,071	22	1,777	48,108	–	–	42,284
1971	12,469	22,748	30,565	388	2,799	68,972	–	–	57,435
1972	13,538	23,125	32,906	576	2,866	72,011	–	–	59,506
1973	13,540	23,351	34,720	853	2,849	75,313	–	–	62,064
1975	14,785	25,009	35,062	3,588	2,780	81,224	–	–	65,061
1980	16,650	25,490	40,774	9,492	2,847	95,253	–	–	74,418
1985	19,170	26,110	47,938	19,229	2,928	115,375	–	–	86,421
1990	21,920	26,006	54,880	34,696	3,031	140,533	–	–	99,964

[1] The energy equivalent of Uranium U_3O_8 shown in Table 6-10 is expressed here as the thermal value of efficiency of use of U_3O_8 in conventional nuclear reactors, assumed to be 33% efficient with a heat rate of 10,250 Btu/Kwh. This gives a thermal value of U_3O_8, under present technology of reactor efficiency, equal to less than 1 percent of the theoretical maximum thermal value of U_3O_8.

[2] The energy equivalent of hydroelectric power, shown in kilowatt hours in Table 6-10, represents the theoretical thermal value of resources required to produce one kilowatt hour of electricity in a fossil-fueled steam electric plant. The calculations for these theoretical inputs for hydropower are based on national average heat rates for steam electric plants during the year indicated.

[3] The total energy equivalent of inputs of fossil and fissile fuels for steam electric plant generation, and the theoretical inputs to hydroelectric power generation, shown in Table 6-10, are calculated from their respective average "heat rates," which represent the thermal efficiencies of each type of generation.

[4] The energy equivalent of electricity purchased and distributed is converted at the standard thermal value of one killowatt hour, or 3412 Btu/kwh.

Source: Tables 6-14, 6-15, 6-16, and 6-17, data for 1972, 1973 from Bureau of Mines News Release March 13, 1974 and FPC News Release May 24, 1974 (electricity).

Prepared by: Office of Economics, Federal Power Commission

Source: FPC, 1975b, National Gas Survey, Vol. 1, Chap. 6,
Tables 6-11, 6-14 and 6-17;

Total consumption of gas in the United States in 1990 under the Base Case assumptions for Case II is 25.2 Tcf, of which 2.7 Tcf is assumed to be Alaskan gas. Coal consumption is projected as 909 million tons or 30 percent above the 1973 level; petroleum is projected at 9.9 billion barrels in 1990, up 78 percent from 1973. Uranium use for nuclear power in the projection is up 2600 percent from 1973 consumption and hydroelectric power by 1990 is only up 14 percent over 1973 (Tables 8-1 and 8-2).

Total remaining recoverable finite energy resources, discovered and undiscovered in the United States, are estimated by the Geological Survey and other sources to be the equivalent of 37.3 quintillion (Q) Btu (Table 8-3). About one-eighth of this or 4.8 Q Btu is presently classified as proved recoverable reserves. However, the domestic resource base is heavily weighted by the coal component, which is about 85 percent of both recoverable resources and proved reserves of energy resources. The remaining 15 percent of recoverable energy resources consists of about 6 percent natural gas, 6 percent petroleum, and 3 percent low cost uranium.

Similar information covering U.S. energy sources to the year 2000 has been included in a 1975 publication of the U.S. Bureau of Mines by Dupree and Corsentino (1975). The facts agree substantially with those already presented above so have not been included here.

Every energy source in the United States can be treated as a separate entity, but in fact each kind of fuel has various advantages and disadvantages both in economic and environmental terms. There is competition among various fuels and trends in use of one or another (Averitt and Carter, 1970). An immediate question is whether the present use of fuels in the United States can be modified by substitution of one for another; this is quite apart from the issue of conservation which might save some energy if measures were rigorously applied. Use of gas in 1972 is shown in figure 8-2. In a large, essentially point-source of consumption, substitution of fuel may be made with some ease. For example, electric power plants which in the last few years have converted from coal to petroleum products to meet environmental standards can be converted back to coal burning and appropriate additional measures taken to curb pollution. Technology is available and the questions are to a large degree based on economic arguments not environmental problems. Almost 16 percent of total gas usage could be allocated to other markets if such conversion were made.

In other large point-source consumptions, as in the petrochemical industry, natural gas serves as feedstock. For some processes no other chemical may be substituted and, if the process is to continue, gas from another source, such as synthetic natural gas from coal or shale oil, must be provided. Substitution of some of the 28.4 percent of gas employed for general industrial use could be made easily, some with moderate difficulty and some only under exceedingly difficult circumstances.

Between these two extremes lies the region of multiple small sources of natural gas use with manifold difficulties in substitution of one fuel for another. The residential sector uses near 21 percent of all natural gas, with more than 135 million Americans living in houses heated by natural gas. Conversion of single family dwellings, built for 30 years of use in America, to either coal-fired hot water heat or electrical heat would require an investment of $2,500 to $5,000 on the part of each homeowner if a house could be converted.

One may conclude that at least one-third of the present consumption of natural gas and perhaps two-thirds is not substitutable during the time frame of the proposed project. Because there is already a shortage of natural gas reported (U.S. Congress, House of Representatives, Comm. Govt.

Table 8-3 Estimated world supply function for finite commercial energy resources

	Natural gas			Petroleum and natural gas liquids			Coal			Uranium (U_3O_8)			Total		
	Q Btu	Percent	Percent	Q Btu	Percent	Percent	Q Btu	Percent	Percent	Q Btu[1]	Percent	Percent	Q Btu	Percent	Percent
Remaining recoverable resources:[2]															
United States	2.6	16		2.7	20		31.1	16		1.4	41		37.8	17	
Rest of world	13.9	84		10.9	80		158.5	84		2.0	59		185.3	83	
World	16.5	100		13.6	100		189.6	100		3.4	100		223.1	100	
			7.3			6.1			85.1			1.5			100
Proved recoverable reserves:[3]															
United States	.3	16		.2	6		4.0	68		.2	33		4.7	40	
Rest of world	1.6	84		3.2	94		1.9	32		.4	67		7.1	60	
World	1.9	100		3.4	100		5.9	100		.6	100		11.8	100	
			16.0			28.6			50.4			5.0			100

[1] The Btu value of uranium U_3O_8 is based on the thermal efficiency of U_3O_8 used in conventional light water reactors, operated at a plant factor of 7%, and with an average heat rate of 10,250 Btu/Kwh, or at 33% efficiency. Theoretical maximum energy equivalent of U_3O_8 is approximately 120 times greater.

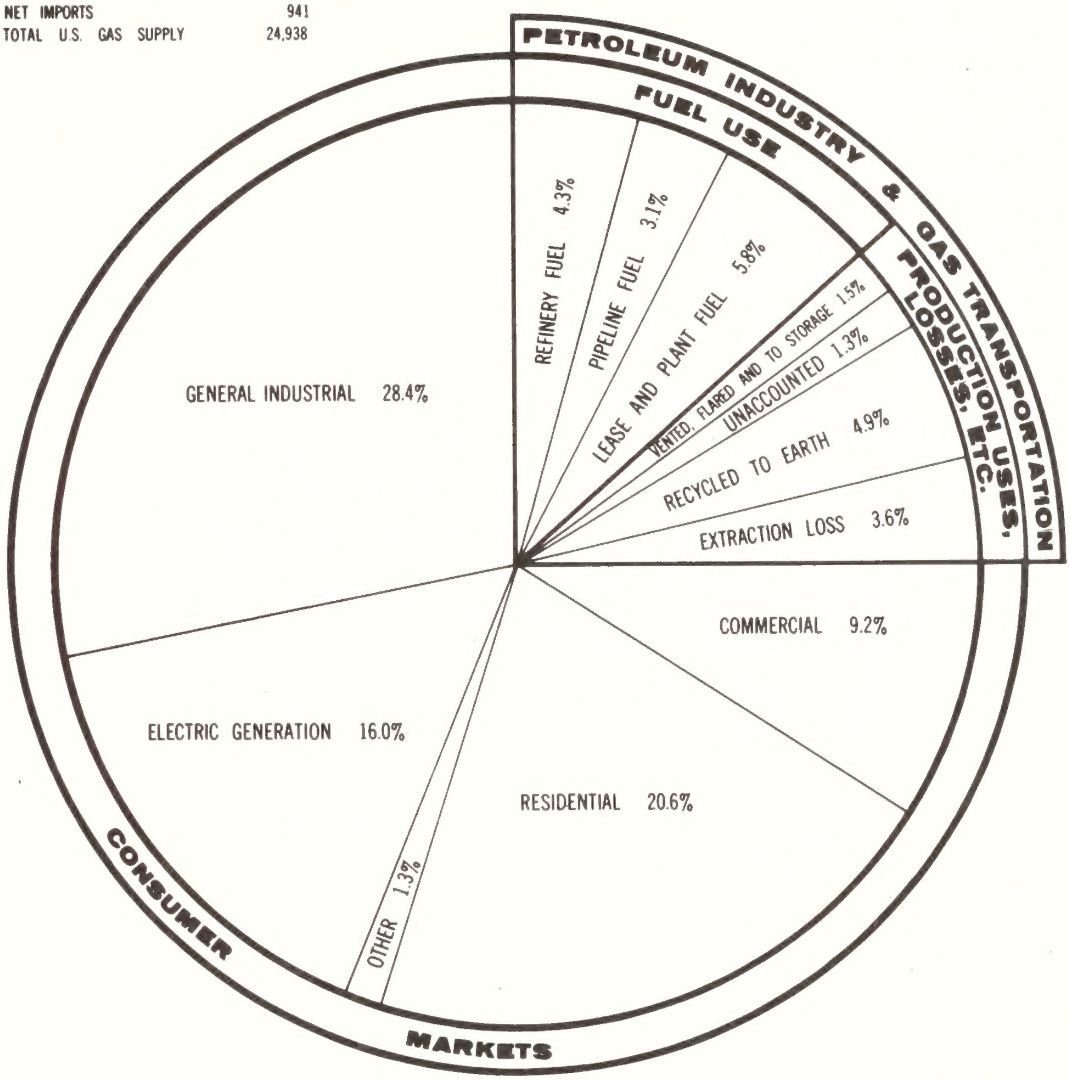
[2] Estimated remaining recoverable resources, discovered and undiscovered, that could be made available under certain economic and technological conditions.

[3] Proved reserves are those recoverable under existing economic and operating conditions, at current prices and under existing technology.

Source: FPC, 1975b, National Gas Survey, Vol. I, Chap. 6, Tables 6-3 to 6-8.

Prepared by: Office of Economics, Federal Power Commission.

	Billion Cubic Feet
GROSS DOMESTIC PRODUCTION	23,997
NET IMPORTS	941
TOTAL U.S. GAS SUPPLY	24,938



Source: U.S. Bureau of Mines Mineral Industry Surveys, September 7, 1973, FPC, 1975b, National Gas Survey, Vol. I, Chap. 2, Figure 2-8

Figure 8-2 Disposition of U.S. gas supply - 1972

Operations, 1975; California State Assembly, 1975; Time, 1975a), it would appear that even rapid substitution of other fuels would still leave some uncertainty as to whether nonsubstitutable needs may be filled.

8-C. Alternative Domestic Natural Gas Supply Systems

In the past, natural gas consumed in the United States has been produced by conventional onshore and offshore oil and gas wells located in the conterminous United States, or supplied by overland pipeline imports from Canada and Mexico. Recently LNG has been imported. For several years these sources combined have not been able to meet the rapidly growing demand. For natural gas, or a substitute natural gas, to meet its projected share of our future energy needs, the current gas situation would have to be drastically changed. The future gas supply of the United States through the year 1990 will consist of: production from domestic oil and gas wells; foreign supplies imported by both pipeline and as liquefied natural gas (LNG); and synthetic natural gas (SNG). (Production of SNG is considered briefly under Coal as an alternative energy source.) This domestic gas section is based largely on information taken from the "National Gas Survey, Vol. I, The Commission Report" (FPC, 1975b) and provided by the Office of Economics of the Federal Power Commission.

8-C-1. Resource Base

The total domestic natural gas resource base is composed of the reserves already found, plus the potential resources yet to be discovered. Definitions of resource terms are given in Appendix II. An additional term, "ultimate-potential supply," is used in the National Gas Survey (1975b). It refers to that portion of the total natural gas resource base that may ultimately be found and produced. This is a realistic approach, for part of the total domestic gas resource base may never be discovered, and large volumes of gas that have been, or may be found, will never be produced because of economic or technologic constraints.

For natural gas, the ultimate-potential supply can be divided into two principal categories, discovered supplies, and undiscovered or potential supplies. The category of discovered supplies includes both natural gas that already has been produced and the remaining proved recoverable reserves. Of the gas that has been discovered or is known to exist, an estimated 300 Tcf (termed submarginal resources by the USGS) is in relatively impermeable reservoirs located in the Rocky Mountain States. Gas resources in this category are not included in the ultimate-potential gas supply, because they are not recoverable under current economics and technology. If technology, such as nuclear stimulation or massive hydraulic fracturing, is developed to make the production of these resources feasible, they will then be reclassified as either proved reserves, or potential supply, depending upon their stage of development.

Another possible source of gas, not included in estimates of ultimate-potential natural gas supply, is methane gas contained in coal. It is estimated that the minable coal beds of depths of less than 3,000 feet in the U.S. may contain 260 Tcf of natural gas. This is about the same quantity as the currently proved natural gas reserves. Methane gas is a by-product of the process which transforms plant substances into coal. Under proper burial conditions, methane cannot escape the coal bed. Methane gas contained in coal is produced to some extent in Europe and in small quantities domestically, but it is too early to predict if this resource will eventually become a viable source of supplementary gas. In addition to technological problems of production, its rate of recovery will depend on the rate of coal mining. If it is eventually determined that coal-contained methane gas is commercially recoverable, this resource probably would be reclassified and included in the domestic ultimate-potential gas supply; currently it is entirely speculative.

Potential gas supply estimates consist primarily of undiscovered gas resources. As defined by the Potential Gas Committee (Potential Gas Agency, Mineral Resources Institute, Colorado School of Mines Foundation, Inc., Golden, Colorado), potential supply is gas that will be found and proved by test wells. These wells may be drilled in the future under the assumed conditions of adequate but reasonable prices, and normal improvement in technology. The Potential Gas Committee (PGC), which makes biennial estimates of potential gas supplies, divides its estimate into three categories of decreasing reliance. Probable supply is associated with existing fields, and includes both discovered and undiscovered reserves. (Figure 8-3 shows the current movement by pipeline of gas in the conterminous United States.) Possible supply is in undiscovered fields in areas of established production. Speculative supply is in untested territories or formations where there is no production and estimates are based on a minimum amount of information.

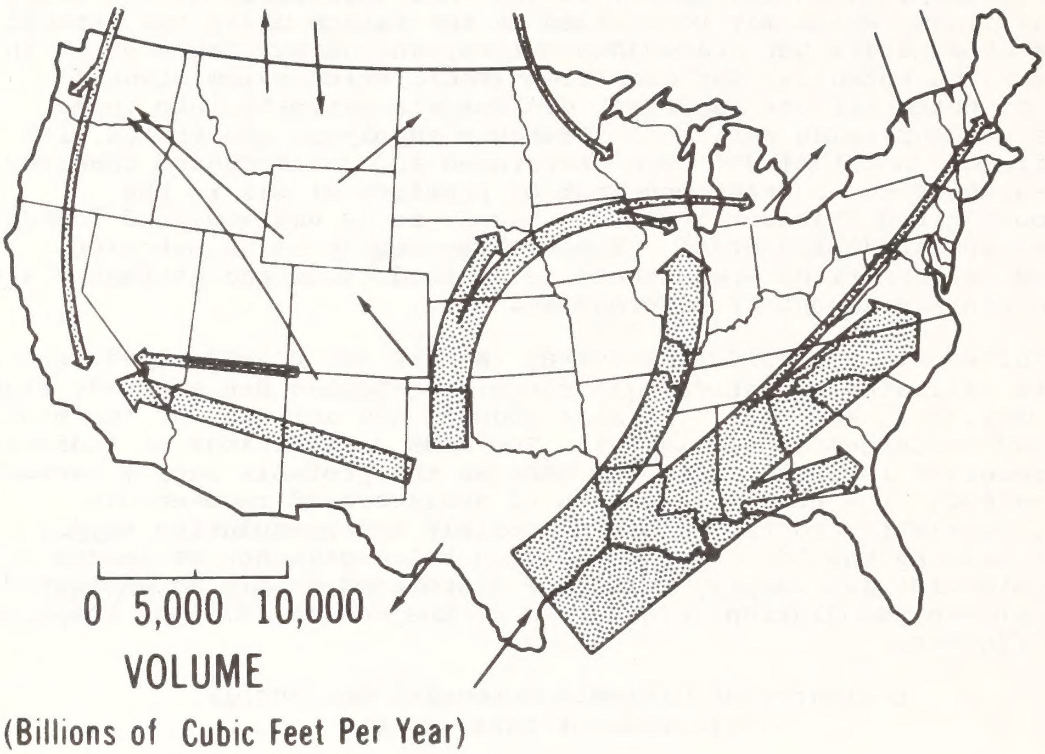
The United States Geological Survey (Miller and others, 1975) recently revised its estimates of natural gas resources (Tables 8-4 and 8-5; Figures 8-4, 8-5, 8-6, 8-7, and 8-8). It also adopted new definitions for mineral reserves and resources (Appendix II). The USGS designations of indicated-inferred reserves is essentially the same as the probable supply category used by the PGC. The USGS designation of undiscovered recoverable resources, is similar to the combined possible and speculative supply categories used by the PGC. The tabulation below presents estimates of the ultimate-potential gas supply, using the discovered supply as estimated by the American Gas Association (A.G.A.) as of the end of 1973 and compared with USGS figures.

Estimates of Ultimate-Potential Gas Supply
(trillions of cubic feet)

	PGS	Order of Reliance
1. Discovered Supply (A.G.A.)	705	
a. Cumulative Production (A.G.A.)	455	1
b. Proved Reserves (A.G.A.)	250	2
2. Potential Supply	1,146	
a. Probable	266	3
b. Possible	384	4
c. Speculative	496	5
3. Ultimate-Potential Supply (1+2)	1,851	
4. Remaining Ultimate-Potential Supply (3-1a)	1,396	

Of the five basic categories of supply listed in the tabulation the cumulative production is the only category that can be measured with any great degree of accuracy. This natural gas has already been used and must be deducted from estimates of future supply. Each of the other categories is an estimate based on information ranging from considerable geologic and engineering data for proved reserves, to geophysical and inferred geologic data for both possible and speculative supplies.

Table 8-6 shows comparisons of six different estimates of ultimate-potential supply.



Source: FPC, 1975b, Figure 2-7

Figure 8-3 Interstate movements of natural gas in 1970

Table 8-4 Production, reserves, and undiscovered recoverable resources of natural gas and natural gas liquids for the United States, December 31, 1974 (onshore and offshore to water depth of 200 meters)

Area	Cumulative Production	Reserves			Undiscovered Recoverable Resources
		Demonstrated			
		Measured[2]	Indicated[3]	Inferred[4]	Range[5,6] (95%-5%)
Natural Gas[1] (Trillions of cubic feet)					
Lower 48 Onshore-----------	446.366	169.454	Not Applicable	119.4	246 - 453
Alaska Onshore-------------	0.482	31.722		14.7	16 - 57
Total Onshore------------	446.848	201.176		134.1	264 - 506
Lower 48 Offshore----------	33.553	35.811		67.4	26 - 111
Alaska Offshore------------	0.423	0.145		0.1	8 - 80
Total Offshore-----------	33.976	35.956		67.5	42 - 181
Total Onshore and Offshore-------------	480.824	237.132		201.6	322 - 655
Natural Gas Liquids (billions of barrels)					
Total Onshore and Offshore-	15.730	6.350	Not Applicable	6	[7] 11 - 22

[1] Cumulative production and estimates of reserves and resources reflect an assumed recovery of about 32 percent of the oil and 80 percent of the gas-in-place. Some portion of the remaining oil-in-place is recoverable through application of improved recovery techniques. Estimates are based on figures released by the American Petroleum Institute (API) and the American Gas Association (AGA) in April 1975.

[2] Identified resources that can be economically extracted with existing technology. Estimates are the "proved reserves" of the API and AGA.

[3] Not applicable.

[4] Resources estimated to be recoverable in the future as a result of extensions, revisions of estimates, and new pays in known fields beyond those shown in indicated reserves.

[5] The low value of the range is the quantity associated with a 95 percent probability (19 in 20 chance) that there is at least this amount. The high value is the quantity with a 5 percent probability (1 in 20 chance) that there is at least this amount. Totals for the low and high values are not obtained by arithmetic summation; they are derived by statistical methods.

[6] **The reader is cautioned against averaging ranges. Statistical mean values are shown in tables 4 and 5 of U.S.G.S. Circular 725.**

[7] The calculated estimates of undiscovered recoverable resources are derived from natural gas estimates by applying historical NGL/Natural Gas ratios. These figures suggest that if added to crude oil estimates, natural gas liquids would increase the estimates of petroleum liquids by approximately 20 percent.

Source: Miller, B. M., and others, U.S. Geological Survey Circular 725, 1975, Table 1.

Table 8-5 Production, reserves, and undiscovered recoverable gas resources for the United States, December 31, 1974 (trillion cubic feet)

Regions	Cumulative Production	Demonstrated Reserves	Total Cumulative Production + Demonstrated Reserves	Inferred Reserves[1]	Undiscovered Recoverable Resources	
		Measured			Statistical Mean	Estimated Range[2] (95%-5%)
ONSHORE						
1. Alaska	0.482	31.722	32.204	[3] 14.7	32	16 - 57
2. Pacific Coastal States	25.455	4.732	30.187	4.0	13	8 - 20
3. Western Rocky Mountains	10.728	9.081	19.809	2.9	14	6 - 25
4. Northern Rocky Mountains	11.485	6.754	18.240	5.3	29	18 - 47
5. West Texas and Eastern New Mexico	58.686	24.624	83.310	23.3	70	35 - 101
6. Western Gulf Basin	197.899	81.903	279.802	58.7	133	85 - 196
7. Mid-Continent	107.700	34.150	141.850	20.6	72	50 - 101
8. Michigan Basin	0.558	1.458	2.016	0.8	1	0.8 - 2
9. Eastern Interior	2.797	0.766	3.563	0.5	2	0.7 - 4
10. Appalachians	31.057	5.985	37.042	3.3	10	5 - 17
11. Eastern Gulf and Atlantic Coastal Plain	0.001	0.001	0.002	[4] Negl.	1	0.4 - 2
Total Lower 48 Onshore	446.366	169.454	615.820	119.4	345	246 - 453
Total Onshore United States	446.848	201.176	648.024	134.1	377	264 - 506
OFFSHORE (0-200 metres)						
1A. Alaska	0.423	0.145	0.568	[3] 0.1	44	8 - 80
2A. Pacific Coastal States	1.415	0.463	1.878	0.4	3	2 - 6
6A. Gulf of Mexico	32.138	35.348	67.486	67.0	50	18 - 91
11A. Atlantic Coastal States	0.000	0.000	0.000	0.0	10	[5] 5 - 14
Total Lower 48 Offshore	33.553	35.811	69.364	67.4	63	26 - 111
Total Offshore United States	33.976	35.956	69.932	67.5	107	42 - 181
Total Lower 48	479.919	205.265	685.184	186.8	408	286 - 529
Total Alaska	0.905	31.867	32.772	14.8	76	29 - 132
TOTAL UNITED STATES	480.824	237.132	717.956	201.6	484	322 - 655

[1] Inferred reserves were derived for all regions based on historical data (See Appendix).

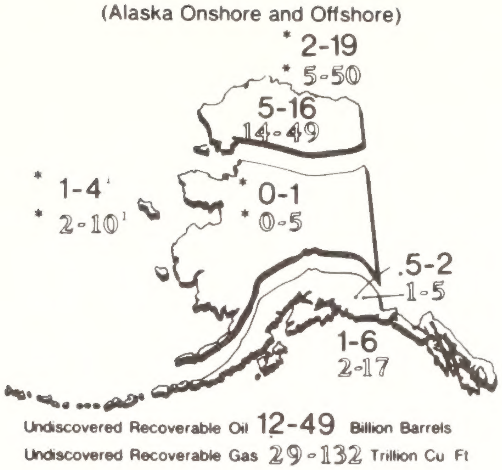
[2] The low value of the range is the quantity associated with a 95 percent probability (19 in 20 chance) that there is at least this amount. The high value is the quantity with a 5 percent probability (1 in 20 chance) that there is at least this amount. Totals for the low and high values are not obtained by arithmetic summation; they are derived by statistical methods.

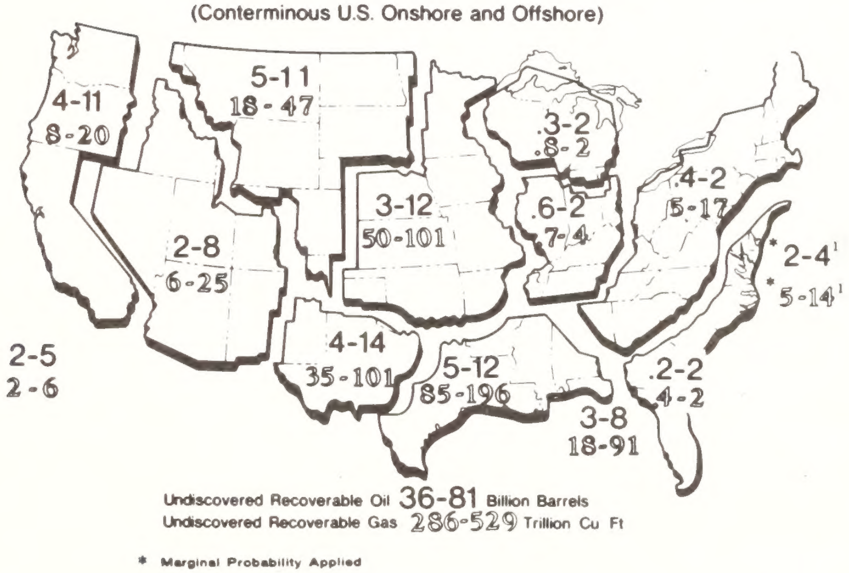
[3] Inferred reserves based on national onshore average.

[4] Negligible--less than 0.001 trillion cubic feet.

[5] Estimates reported at the 75 and 25 percent probability levels because, in this area, these levels are judged to be more applicable for some planning purposes. It can also be noted that in frontier areas, lacking discovered indigenous or adjacent recoverable hydrocarbons, uncertainty is sufficiently great as to weaken probability estimates at extreme ranges. For purposes of comparison with other recorded ranges, the 95-5 percent probability range in offshore Atlantic is 0-22 trillion cubic feet of gas.

Source: Miller, B. M., and others, U.S. Geological Survey Circular 725, 1975, Table 5.

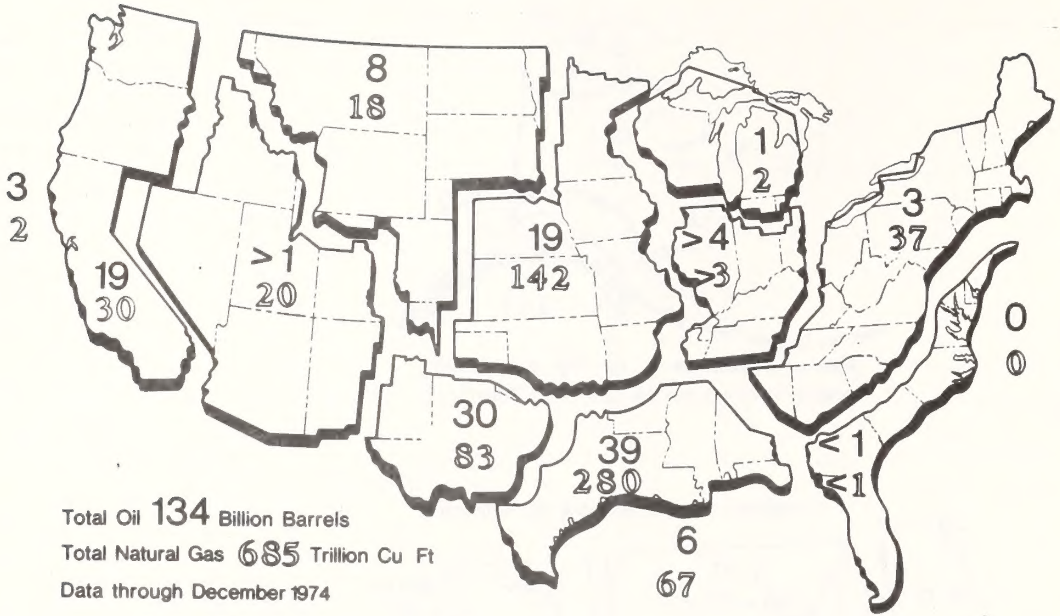

(Alaska Onshore and Offshore)
* 2-19
* 5-50
5-16
14-49
* 1-4[1]
* 2-10[1]
* 0-1
* 0-5
.5-2
1-5
1-6
2-17
Undiscovered Recoverable Oil 12-49 Billion Barrels
Undiscovered Recoverable Gas 29-132 Trillion Cu Ft


(Conterminous U.S. Onshore and Offshore)
4-11
8-20
5-11
18-47
.3-2
.8-2
.4-2
5-17
3-12
50-101
.6-2
7-4
2-8
6-25
* 2-4[1]
* 5-14[1]
2-5
2-6
4-14
35-101
5-12
85-196
.2-2
.4-2
3-8
18-91
Undiscovered Recoverable Oil 36-81 Billion Barrels
Undiscovered Recoverable Gas 286-529 Trillion Cu Ft
* Marginal Probability Applied

Source: Miller, B. M., and others, U.S. Geological Survey Circular 725, 1975, Figure 1

[1] Estimates reported at the 75 and 25 percent probability levels because, in these frontier areas, these levels are judged to be more applicable for some planning purposes. It can also be noted that in frontier areas, lacking discovered indigenous or adjacent recoverable hydrocarbons, uncertainty is sufficiently great as to weaken probability estimates at extreme ranges. For purposes of comparison with other recorded ranges, the 95-5 percent probability range in the Bering Sea is 0-8 billion barrels of oil and 0-18 trillion cubic feet of gas; in the offshore Atlantic it is 0-6 billion barrels of oil and 0-22 trillion cubic feet of gas.

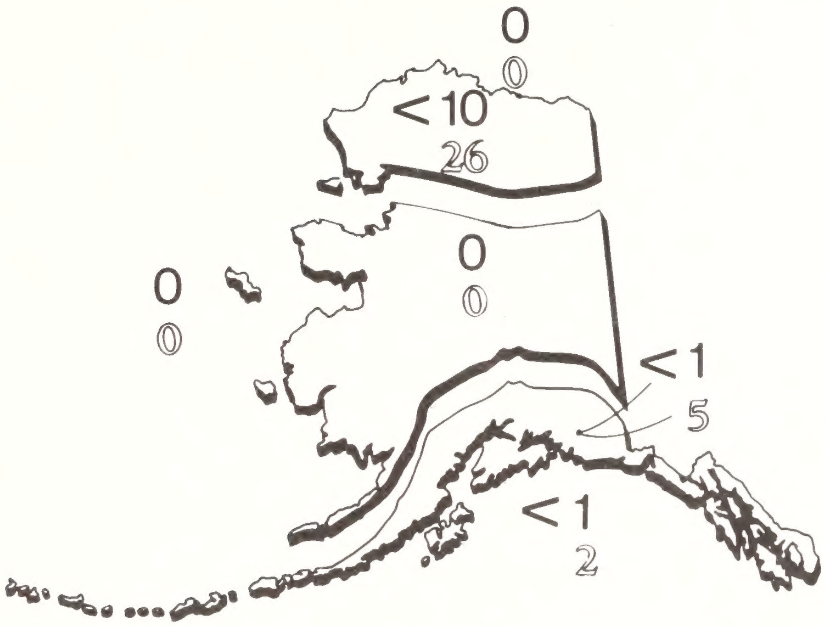
Figure 8-4 Undiscovered recoverable resources of crude oil and natural gas for the United States. (Reported as a range of values at 95-5 percent probability in billions of barrels for oil and trillions of cubic feet for gas.)



8
18
3
2
19
30
>1
20
19
142
1
2
>4
>3
3
37
0
0
30
83
39
280
6
67
<1
<1
Total Oil 134 Billion Barrels
Total Natural Gas 685 Trillion Cu Ft
Data through December 1974

Source: Miller, B. M., and others, U.S. Geological Survey Circular 725, 1975, Figure 9

Figure 8-5 Cumulative production and demonstrated reserves of oil and natural gas by regions for the conterminous United States, onshore and offshore to 200 meters



Total Oil-11 Billion Barrels

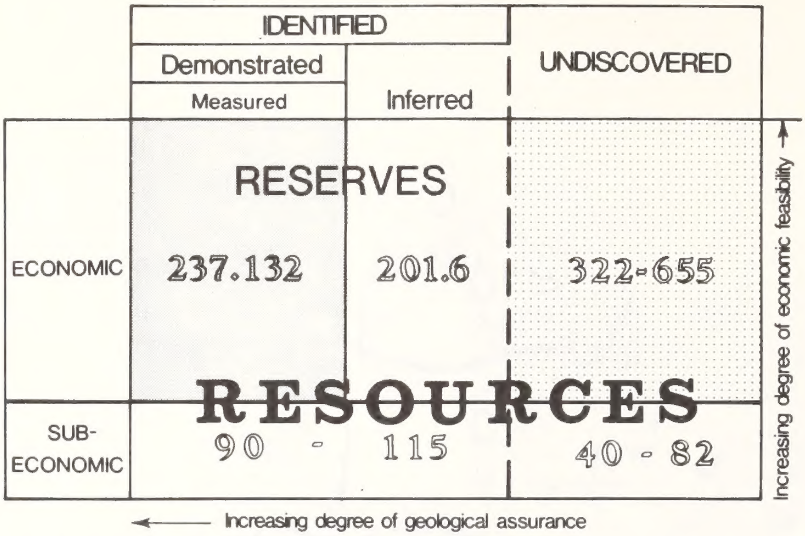
Total Natural Gas-33 Trillion Cu Ft

Data through December 1974

Source: Miller, B. M., and others, U.S. Geological Survey Circular 725, 1975, Figure 10.

Figure 8-6 Cumulative production and demonstrated reserves of oil and natural gas by regions for Alaska, onshore and offshore to 200 meters

NATURAL GAS RESOURCES OF THE UNITED STATES (TRILLION CUBIC FEET)

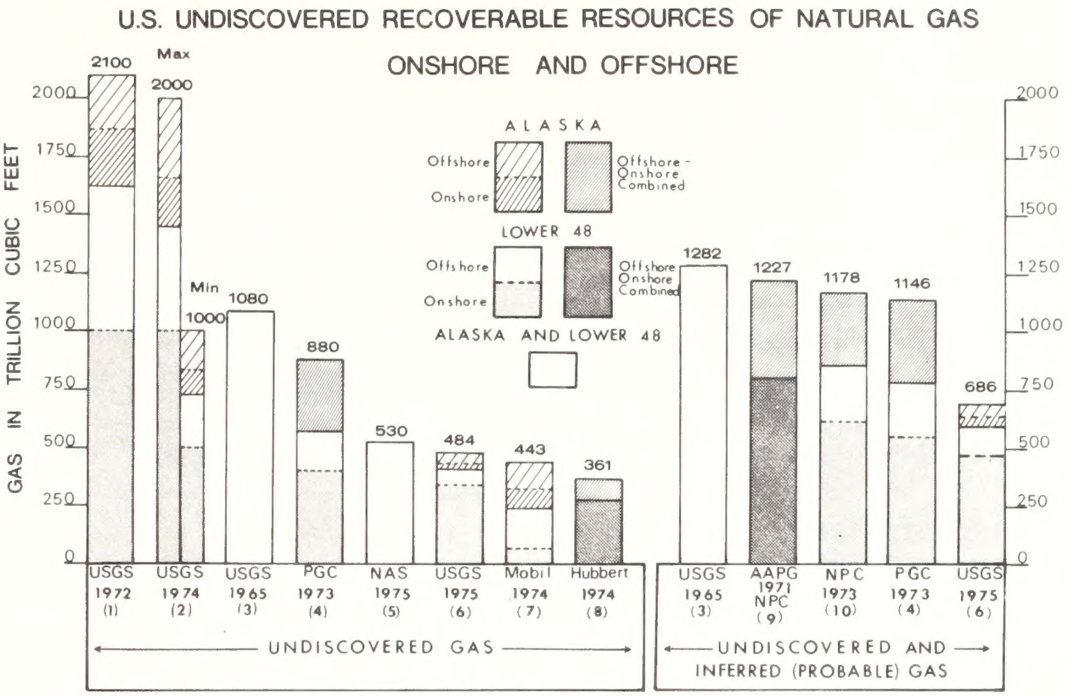

RESERVES
RESOURCES
Increasing degree of economic feasibility
Increasing degree of geological assurance

	IDENTIFIED		UNDISCOVERED
	Demonstrated	Inferred	
	Measured		
ECONOMIC	237.132	201.6	322-655
SUB-ECONOMIC	90 - 115		40 - 82

Total U.S. Cumulative Gas Production 481 Trillion Cu Ft 12/31/74

Source: Miller, B. M., and others, U.S. Geological Survey Circular 725, 1975, Figure 14

Figure 8-7 Diagrammatic representation of estimated natural gas resources using the U.S. Geological Survey's resource classification system (modified from McKelvey, 1973). Cumulative gas production is cited below the figure.



(1) Theobald and others, U.S. Geol. Survey Circ. 650, 1972. Includes water depth to 2,500 m (8,200 ft).

(2) U.S. Geol. Survey News Release, March 26, 1974. Includes water depth to 200 m (660 ft).

(3) Hendricks, U.S. Geol. Survey Circ. 522, 1965. Adjusted through 1974. Includes water depth to 200 m (660 ft).

(4) Potential Gas Committee, "Potential supply of natural gas in the United States," 1973. Includes water depth to 460 m (1,500 ft).

(5) Nat'l. Academy of Sciences, "Mineral Resources and the Environment," 1975. (See National Research Council). Water depth not indicated.

(6) U.S. Geol. Survey Mean , Oil and Gas Branch Resource Appraisal Group, 1975. Includes water depth to 200 m (660 ft).

(7) Mobil Oil Corp., Expected Value: Science, 12 July 1974. (See Gillette). Includes water depth to 1830 m (6000 ft).

(8) Hubbert, Senate Committee Report, 1974. Includes water depth to 200 m (660 ft).

(9) Am. Assoc. Petroleum Geologists Mem. 15, 1971. Also National Petroleum Council, "Future petroleum provinces of the United States," 1970. Some areas are excluded from this estimate. Includes water depth to 2,500 m (8,200 ft).

(10) National Petroleum Council, "U.S. energy outlook -- oil and gas availability," 1973. Includes water depth to 2,500 m (8,200 ft).

Source: Miller, B. M., and others, U.S. Geological Survey Circular 725, 1975
Figure 38

Figure 8-8 Comparative estimates of natural gas resources in the United States

Table 8-6 Comparison of ultimate-potential supply estimates (trillion cubic feet) as of December 31, 1973

Area	AGA 12-31-73		Discovered supply (1) + (2) (3)	Potential supply (4)	Ultimate potential supply (3) + (4) (5)	Source date (6)
	Cumulative production (1)	Proved reserves (2)				
Lower 48 States	455	218	673	780	1,453	PGC (V)
Alaska	1	32	32	366	398	1973
Total U.S.	456	250	705	1,146	1,851	
Lower 48 States	455	218	673	840-1,670	1,513-2,343	USGS[2] (V)
Alaska	1	32	32	290-580	322-612	1974
Total U.S.	456	250	705	1,130-2,250	1,835-2,955	
Lower 48 States	455	218	673	377	1,050	Hubbert (M)
Alaska	1	32	32	118	150	1969
Total U.S.	456	250	705	494	1,200	
Lower 48 States	455	218	673	380-553	1,053-1,226	Linden (M)
Alaska	1	32	32	179-135	211-167	1972
Total U.S.	456	250	705	558-687	1,264-1,393	
Total U.S.	456	250	705	294	1,000	Weeks (M) 1959
Total U.S.	456	250	705	841	1,547	Moore (M) 1970

[1] Adapted in part from "Energy Resources of the United States" Geological Survey Circular 650, Figure 16, p. 16.

[2] Includes only estimated recoverable resources to 200 meters water depth.

(V) Volumetric or geological method.
(M) Mathematical projection.

Note: Totals may not add due to rounding.

Source: FPC, 1975b, Narional Gas Survey, Vol. I, Chap. 9, Table 9-3.

The National Gas Survey Case II projections of natural gas supply availabilities to 1990 are included in Table 8-7. Note that these projections include gas deliveries from Alaska roughly comparable to the scheduled deliveries of the Alaska Natural Gas Transportation System.

8-C-2. Economic and Technological Feasibility of Substitution

Rate of development of future new supplies onshore in the conterminous United States will probably be more responsive to changes in the wellhead price of gas than any other factor. Rate of development of future offshore supplies is probably more dependent upon the rate and size of lease sales. Rate of development for potential supplies in Alaska in areas other than the North Slope, and availability of these supplies to major domestic market areas, will be determined by development of an adequate system of transportation. The frequency and size of lease sales in Alaska, both onshore and offshore, will also be a major factor in development of Alaska's other potential gas resources.

Table 8-8 shows the range of projected, conventional, future gas supplies for the conterminous United States from 1970-1990. Four cases of projected supplies are included in this table. They range from Case I, the conservative situation, which assumes that present trends will continue, to Case IV, which presents the maximum supply expected to be available from each source. The "Conservative realistic" situation, Case II, is based on the following criteria:

a) Onshore--Nonassociated gas forecasts were based on National Gas Survey projections. The National Gas Survey used a hypothetical price schedule ranging from 34¢/Mcf in 1975, to 58¢/Mcf in 1990 (adjusted for inflation). The associated-dissolved gas projection was the same as Case I.

b) Offshore--Development will occur in all the offshore areas. This is based on the successful exploitation of leases included in the accelerated OCS leasing program.

c) Alaska--It is assumed that a pipeline outlet from Alaska's North Slope to markets in the Lower 48 States will be completed by 1984.

d) Pipeline imports--Some additional imports from Canada's traditional supply areas will be authorized and large diameter pipelines will be constructed from the Mackenzie Delta and the Arctic Islands to markets in the conterminous United States by 1984 and 1989.

e) LNG imports--This is the same as Case I, and additionally assumes that all projects currently filed with the FPC will reach fruition.

f) Stimulation of low-permeability reservoirs--The projections for this source were determined by averaging low production cases for nuclear and hydraulic fracturing, and applying a production delay of five years.

g) Substitute natural gas from both foreign and domestic sources.

The coal gasification projection assumes that four plants will be in operation by 1980, increasing to 27 by 1990. Gas from liquid hydrocarbons assumes that all the naphtha plants currently under construction will be completed, plus 50 percent of the proposed "probable" plants will be constructed. One-third of the proposed crude oil plants will be constructed by 1980 and one additional plant will be constructed every second year beginning in 1981.

Table 8-7 Future available gas supply

[Trillion Cubic Feet]

	Actual 1970	Case I				Total 1971-90	Case II				Total 1971-90	Case III				Total 1971-90	Case IV				Total 1971-90
		1975	1980	1985	1990		1975	1980	1985	1990		1975	1980	1985	1990		1975	1980	1985	1990	
Natural gas from domestic sources	22.0	22.2	19.1	15.1	11.2	359	22.5	20.6	20.0	17.9	408	22.6	24.7	23.6	22.8	465	22.6	27.7	29.6	32.5	542
Gas from conventional sources[1]	22.0	22.2	19.1	15.1	11.2	359	22.5	20.5	19.5	16.9	403	22.6	24.2	22.6	21.3	453	22.6	26.5	26.6	27.9	508
Lower 48 States	21.8	22.0	18.9	14.8	10.9	355	22.3	20.3	17.6	14.3	387	22.4	22.3	20.2	17.6	420	22.5	24.3	23.5	22.2	462
Onshore	18.6	17.7	14.1	11.0	8.3	275	17.9	14.7	12.0	9.6	288	18.0	15.3	13.3	11.3	303	18.0	15.6	14.1	12.5	312
Offshore	3.2	4.3	4.7	3.8	2.6	80	4.4	5.6	5.6	4.7	99	4.4	7.0	6.9	6.3	117	4.5	8.7	9.4	9.7	150
Alaska	.1	.2	.2	.3	.3	4	.2	.2	1.9	2.7	16	.2	1.9	2.5	3.8	33	0.2	2.2	3.1	5.7	47
Gas from stimulation of low-permeability Reservoirs[2]	.0	.0	.0	.0	.0	0	.0	.1	.5	1.0	5	.0	.5	1.0	1.5	12	.0	1.2	3.0	4.6	34
Substitute natural gas from domestic sources	.0	.0	.2	.7	1.2	8	.0	.3	1.1	2.2	12	.0	.4	1.3	3.0	16	.0	.6	1.9	5.1	26
Gas from coal	.0	.0	.2	.7	1.2	8	.0	.3	1.1	2.2	12	.0	.4	1.3	3.0	16	.0	.6	1.9	5.1	26
Gas from oil-shale	.0	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]
Gas from organic waste	[3]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]
Hydrogen	[3]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]
Total supply from domestic sources	22.0	22.2	19.3	15.8	12.4	367	22.5	20.9	21.1	20.1	420	22.6	25.1	24.9	25.8	481	22.6	28.3	31.5	37.6	568
Gas from foreign sources	.8	1.4	2.1	2.2	1.7	35	1.8	3.8	4.2	5.1	67	2.2	6.1	7.7	8.4	110	2.4	7.5	9.5	11.6	136
Pipeline imports[5]	.8	1.0	1.0	.9	.2	17	1.2	1.3	1.4	2.1	28	1.2	1.9	2.2	2.6	40	1.2	2.0	2.9	3.7	50
Liquefied natural gas	[3]	[3]	.4	.4	.4	5	.1	1.5	1.5	1.5	20	.4	2.7	3.8	3.8	45	.4	3.2	3.8	4.7	51
Gas from liquid hydrocarbons[6]	[3]	.4	.7	.9	1.1	13	.5	1.0	1.3	1.5	19	.6	1.5	1.7	2.0	25	.8	2.3	2.8	3.2	35
Gas from methanol	[3]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]
Total supply	22.8	23.6	21.4	18.0	14.1	402	24.3	24.7	25.3	25.2	487	24.8	31.2	32.6	34.2	591	25.0	35.8	41.0	49.2	704

[1] Includes all gas projected to be produced from domestic oil and gas wells.

[2] Includes those low-permeability reservoirs which contain gas that is not commercially producible under current prices and technology.

[3] Less than 0.05 trillion cubic feet.

[4] No estimate made.

[5] Primarily from Canada. Imports from Mexico in 1972 were about 0.008 trillion cubic feet.

[6] Classified as gas from foreign sources because incremental supplies of liquid hydrocarbons must be imported.

Note: Totals may not add due to rounding.

Source: FPC, 1975b, National Gas Survey, Vol. I, Chap. 9. Table 9-1.

Table 8-8 Total lower 48 states projected future natural gas supplies 1/ (trillion cubic feet)

	Actual	Projected				Totals
	1970	1975	1980	1985	1990	1971-1990
Production						
Case:						
I	21.816	21.965	18.790	14.755	10.865	354.625
II	21.816	22.250	20.295	17.590	14.250	387.030
III	21.816	22.395	22.315	20.185	17.555	419.785
IV	21.816	22.490	24.304	23.539	22.240	461.665
Reserve Additions						
Case:						
I	11.123	14.205	11.530	6.190	3.515	189.175
II	11.123	15.585	14.795	12.415	7.655	254.090
III	11.123	16.915	18.650	15.700	10.745	313.575
IV	11.123	17.730	24.685	21.595	16.140	396.545
Year-end Reserves[2]						
Case:						
I	255.612	206.775	172.790	130.905	90.160	
II	255.612	210.190	182.595	155.760	121.345	
III	255.612	213.435	193.380	176.390	148.085	
IV	255.612	214.955	214.165	209.770	189.180	
R/P Ratio						
Case:						
I	11.7	9.4	9.2	8.9	8.3	
II	11.7	9.4	9.0	8.9	8.5	
III	11.7	9.5	8.7	8.7	8.4	
IV	11.7	9.6	8.7	8.9	8.5	

[1] Includes both non-associated and associated-dissolved gas but does not include gas from the stimulation of low-permeability reservoirs.

[2] Does not include reserves held in underground storage which in 1970 amounted to 4.004 Tcf.

Source: FPC. 1975b, National Gas Survey, Vol. I, Chap. 9, Table 9-20.

The FPC estimate for future supply and demand for gas in the United States to 1990 is shown in Table 8-9 which compares gas supply with gas demand. The projected demand under any of the sets of assumptions used by the Federal Power Commission is higher than any but the highest supply case. The highest supply case assumes: (1) significant increase in exploratory effort, (2) improved success in exploration, (3) rapid development of needed new technology, and (4) no delays in any of the program. The more realistic supply assumption used for Case II infers deficits of gas of 3.7 Tcf in 1975 and 20.1 Tcf in 1990, based on gas industry demand projections. The 1990 deficit would be reduced to 11.0 Tcf if the lowest demand projections are used.

Recent developments have not brightened the outlook for future gas supply. Despite an upturn of exploratory and developmental drilling during 1972 and 1973, the gas discovery record in the Lower 48 States has been poor in terms of new reserves added. A number of oil-based substitute natural gas projects have been cancelled because soaring feedstock costs have made them economically impractical. At the same time, delays in nuclear programs indicate that increased pressure on already short supplies of fossil fuels may be expected.

It is unlikely that actual supply will achieve the Case II (conservative-realistic) level if deliveries of Alaska gas under the proposals are denied, because the Case II supply estimates are based on both a level of effort that exceeds that of the past 10 years and an assumption that Alaska gas will be developed. If the supply falls short of the Case II level, it will mean additional curtailments of gas service to consumers and further disruptions of the economy. Assumptions used for this analysis are those for Case II supply which is conservative, but which will require a strong effort on the part of the gas industry.

To achieve a balance between supply and consumption in the past few years, interruptions of gas service, curtailments of firm deliveries, refusal to take on new customers, and refusal to provide increased service to existing customers have been necessary. These actions were undertaken as the gas industry has been forced to respond to the gas shortage. There is now increased recognition that the gas shortage is serious and probably of long duration. Thus, it is apparent that steps to conserve gas and reduce demand, including the use of higher prices, will be necessary if curtailments are to be minimized.

The capital requirements of the gas producing industry from now to 1990 will be different from those of the past, both in character and magnitude. On a constant dollar basis they will be substantially higher per unit of productive capacity for both domestic natural gas and substitute gases. These higher capital costs will impact heavily on the future cost of gas to consumers. Energy industries have always been able to satisfy their investment capital needs without serious problems, but conditions of today's money market and prospective massive capital requirements for these industries and for other segments of the U.S. economy suggest that new financial problems may develop. A review of specific investment requirements for the major categories of future gas supply indicates the growing magnitude of the gas industry's financial needs.

The average cost of drilling and equipping a successful gas well is compared with similar costs for oil wells and dry holes by area in the tabulation below. In addition to the different unit drilling costs for gas wells, oil wells, and dry holes, there is a major difference in the unit drilling costs in each of the three areas.

Table 8-9 Trends in demand and supply for gas (trillion cubic feet)

Year	Projected gas demand	Gas supply[5]				Surplus (shortage)			
		I	II	III	IV	I	II	III	IV
Projected demand[1]									
1975	28.0	23.6	24.3	24.8	25.0	(4.4)	(3.7)	(3.2)	(3.0)
1980	33.4	21.4	24.7	31.2	35.8	(12.0)	(8.7)	(2.2)	2.4
1985	38.4	18.0	25.3	32.6	41.0	(20.4)	(13.1)	(5.8)	2.6
1990	45.3	14.1	25.2	34.2	49.2	(31.2)	(20.1)	(11.1)	3.9
Gas demand high estimate[2]									
1975	30.3	23.6	24.3	24.8	25.0	(6.7)	(6.0)	(5.5)	(5.3)
1980	36.8	21.4	24.7	31.2	35.8	(15.4)	(12.1)	(5.6)	(1.0)
1985	44.0	18.0	25.3	32.6	41.0	(26.0)	(18.7)	(10.4)	(3.0)
1990	52.2	14.1	25.2	34.2	49.2	(38.1)	(27.0)	(18.0)	(3.0)
Gas demand low estimate[3]									
1975	28.6	23.6	24.3	24.8	25.0	(5.0)	(4.3)	(3.8)	(3.6)
1980	31.5	21.4	24.7	31.2	35.8	(10.1)	(6.8)	(0.3)	4.3
1985	34.7	18.0	25.3	32.6	41.0	(16.7)	(9.4)	(2.1)	6.3
1990	36.2	14.1	25.2	34.2	49.2	(22.1)	(11.0)	(2.0)	13.0
Reduced demand through technology[4]									
1975	27.4	23.6	24.3	24.8	25.0	(3.8)	(3.1)	(2.6)	(2.4)
1980	31.8	21.4	24.7	31.2	35.8	(10.4)	(7.1)	(0.6)	4.0
1985	35.0	18.0	25.3	32.6	41.0	(17.0)	(9.7)	(2.4)	6.0
1990	40.3	14.1	25.2	34.2	49.2	(26.2)	(15.1)	(6.1)	8.9

[1] Chapter 7 Table 7-1.
[2] Chapter 7 Table 7-2 Case III.
[3] Chapter 7 Table 7-2 Case II.
[4] Chapter 8 Table 8-2 (High level conservation).
[5] Chapter 9 Table 9-1.

Source: FPC, 1975b, National Gas Survey, Vol. I, Chap. 12, Table 12-1 and tables cited above.

Unit Drilling Costs
(1970 Dollars Per Foot)

Area	Gas	Oil	Dry Holes
Alaska	$209.19	$151.57	$177.91
Lower 48 States Offshore	67.78	60.14	50.97
Lower 48 States Onshore	22.61	14.36	11.95

Source: Joint Association Survey of the U.S. (JAS) Oil and Gas Producing Industry, November 1971; FPC, 1975b, National Gas Survey, Vol. 1, chap. 12, Table 12-6.

Larger and more productive discoveries in Alaska and offshore areas are expected to partially offset the higher drilling costs shown. If gas from Alaska is not delivered, total drilling costs in the Lower 48 States would be much higher, because the best prospects for onshore exploration would be in previously untested, deeper formations where drilling costs are more expensive. While the total drilling costs would be higher than indicated to find additional sources, the additions to reserves and production could be much lower. From 1968 to 1972 approximately 50 Mcf of natural gas were added to the proved reserves for each foot of hole drilled in the conterminous United States onshore area. This compares to about 400 Mcf for each foot drilled in Southern Louisiana's offshore area and about 800 Mcf per foot drilled for Alaska (excluding Prudhoe Bay, for which data are not available).

The best prospects for onshore exploration in the conterminous United States are previously untested deeper formations, where drilling will be more expensive. Even for onshore conterminous United States conventional gas facilities, the investment costs per unit of productive capacity will be much higher in 1990 than they are today. The cost increase to consumers will be gradual, however, as gas from the deeper formations slowly replaces gas now being depleted from the shallower formations. Very little oil has been found at depths below 20,000 feet which may dampen industry zeal for deep exploration and development unless prospects are favorable and prices are attractive. Geochemical speculations suggest that in many areas oil may not occur below 20,000 feet in economically recoverable quantities.

For offshore of the conterminous United States, the cost of acquiring additional undeveloped acreage will be much higher than on the land. The bonus bidding system now used by the Federal government for the Federal offshore domain insures high costs for undeveloped acreage. The Federal government has conducted 32 offshore lease sales from 1954 through the end of 1973 and has received total bonus bids of $9.8 billion. In recent years the average successful bonus bid has been over $2,500 per acre, compared with nominal costs for securing mineral leases on public or private lands onshore in the Lower 48 States.

In addition to the investment required to obtain the necessary supply of domestic gas, there will be additional need for investment in transmission and distribution facilities in the conterminous United States. Distribution companies and transmission companies are becoming more deeply involved in both conventional natural gas exploration and development and in supplemental source gas supply projects. Historical lines between producing, transmission, and distribution segments of the industry are thus becoming blurred and there is some overlap in the future investment requirements being advanced by spokesmen for the three industry components. Further, the level of investment for transmission and distribution facilities can differ depending on the level of supply, the location of supply, and the type of supply.

It is estimated under the Case II assumptions in the National Gas Survey that the natural gas transmission industry's 20-year gross investment needs for the 1970-1990 period would be about $34.9 billion for the Lower 48 States, an average of $1.7 billion per year. The replacement of gas deliveries from both proposals by additional supplies from the conterminous United States would entail additional gross investment needs during the period in the transmission area, if additional capacity is needed.

The investment requirements of the distribution industry are estimated at $40.0 billion for the 1971-1990 period under the Case II assumptions. This is about 2.5 times the 1970 gross plant figures for the distribution industry. This estimate is based on a supply estimate of 25.2 Tcf (used in supply assumptions for Case II).

Both the transmission and distribution segments of the industry in the conterminous United States will experience a substantial need for investment capital during the forecast period to 1990. These capital needs will affect gas cost, and the gas industry may have considerable difficulty in competing for investment dollars in the capital markets.

8-C-3. Deregulation Effects

Deregulation of the price of new natural gas at the wellhead is one measure that has been advocated to alleviate the Nation's severe natural gas supply-demand imbalance. In 1954, the Supreme Court ruled that independent producers of natural gas, whose sale of gas goes into interstate commerce, were subject to price regulation under the Natural Gas Act. Under Deregulation, the Federal Power Commission (FPC) would permit gas prices to rise to the extent needed to attract additional investment in domestic oil and gas exploration and development and thereby lead to production of additional supplies of natural gas.

The FPC has taken various actions in attempts to reverse the increasing gas supply shortfall and to generate adequate and reliable supplies. Actions to date, while helpful, have not had the desired effect. Advocates of deregulation believe that what is required is a return to an economic environment in which the impersonal forces of a free market place determine the supply-demand relationships of gas and other primary energy sources in a competitive energy market.

The environmental impact of deregulation is exactly the same as that of increased production of natural gas on natural and physical systems. An increase in cost would have a socio-economic impact. For example, according to the report of the House Committee on Government Operations (U.S. Congress, House of Representatives, Committee on Government Operations, 1975), a study made by the Library of Congress, Congressional Research Service (1974) indicates that "the additional cost resulting from the deregulation of natural gas prices would be $75.6 billion over the six years following deregulation and $17.7 billion annually thereafter." A great increase in cost might cause a rapid shift to alternative fuel sources. This is so speculative that it cannot be pursued.

One difficulty with the concept of deregulation as a solution to the gas shortage is that it treats natural gas as an infinite quantity, controlled only by price. All natural resources are finite and production begins at a low level, rises to a plateau, and then declines with exhaustion of the resource. The rates are subject to price, but the general shape of the curve of production is unchanged by price. An increase in cost of natural gas will cause industries to look at alternative fuel sources, but, if the speed of change in the cost is rapid, a consideration of alternative fuels will be forced.

A number of econometric models have been built to analyze, predict, and simulate, under varied assumptions, the future impacts of alternative regulatory policies, including various types of natural gas deregulation, on future additions to gas reserves, gas production, and demand for gas.

Among the most sophisticated of these models is that of MacAvoy and Pindyck (1973) constructed to predict the impact of alternative regulatory policies. In a simulation of this model, three alternative cases were considered: (I) Limited deregulation of field prices of new gas (as proposed in Appendix G of Final Environmental Impact Statement on Proposed Deregulation of Natural Gas Prices, U.S. Department of the Interior, June 1974); (II) Strict cost-of-service approach to field prices; (III) Maintenance of the present regulatory status quo. Results are given in Table 8-10.

The Case I simulations of the MacAvoy-Pindyck model given below show levels of gas from conventional domestic sources considerably in excess of the levels shown for Case II Supply in the National Gas Survey, as follows:

Year	Natural Survey Case II* (Tcf)	MacAvoy-Pindyck Case I (Tcf)	Differential (Tcf)
1975	22.5	26.0	3.5
1980	20.5	32.8	12.3
1985	19.5		
1990	16.9		

*FPC, 1975b, National Gas Survey, Vol. I, Chap. 9, Table 9-1, Case II - Conventional Sources Lower 48 States, 1975-1990.

The additional supplies of domestic natural gas available by 1980 under the Case I assumption in the MacAvoy-Pindyck simulation of deregulation of new gas, compared to the Case II projections of supply in the National Gas Survey, considerably exceed the capacity of the proposed Alaska Natural Gas Transportation System of 1.6 Tcf annually by 1985.

However, the contract field price of 65¢/Mcf, for intrastate gas and even interstate gas in some instances, has been invalidated by the major increases in price during 1974. A few emergency sales of gas in the interstate market, for example, exceeded the 65¢/Mcf level. At the beginning of 1975 the Uniform National Rate for new gas in the interstate market was 52¢/Mcf. Intrastate gas sells considerably in excess of $1.00/Mcf. This rapid shift in the short-run pricing of gas does not necessarily invalidate the MacAvoy-Pindyck model, but the new price structure for gas will require a rerun of the model under new price assumptions.

The Project Independence Report issued by the Federal Energy Administration in November 1974 included a simulated model of future domestic natural gas production possibilities and minimum acceptable prices for natural gas, given here in Tables 8-11 and 8-12. The simulations were carried out under the Project Independence assumptions common to both the Business as Usual (BAU) case and the Accelerated Development (AD) case. Included in the assumptions for both cases is economic regulation of natural gas prices where prices are allowed to rise to the market clearing level, or deregulation of new gas supplies. The Project Independence projections of

Table 8-10 Simulation results of MacAvoy-Pindyck model for different policy alternatives

Year	New Contract Field Price (¢/Mcf)	Additions to Reserves (Tcf)	Production Supply (Tcf)	Production Demand (Tcf)	Excess Demand (Tcf)	Average Wholesale Price (¢/Mcf)
I. Limited Deregulation (Administration Policy)						
1972	26.3	9.8	19.3	23.3	4.1	33.6
1973	29.6	12.7	22.1	24.4	2.3	36.7
1974	44.1	13.8	25.0	25.4	0.3	42.0
1975	47.7	15.4	26.0	26.4	0.3	45.8
1976	51.3	18.3	27.1	27.4	0.3	49.5
1977	54.9	22.2	28.2	28.5	0.3	53.3
1978	58.4	25.9	29.5	29.7	0.2	57.1
1979	62.0	29.9	31.0	31.0	0.0	61.0
1980	65.5	34.6	32.8	32.4	-0.3	64.9
II. Cost of Service Regulation (Senate Committee Policy)						
1972	26.3	9.8	19.3	23.3	4.0	33.5
1973	29.6	12.7	22.0	24.3	2.3	36.6
1974	30.5	13.8	22.8	25.6	2.8	38.4
1975	31.3	15.2	23.4	26.9	3.6	40.1
1976	32.1	16.8	24.0	28.5	4.5	41.7
1977	33.0	18.7	24.7	30.3	5.5	43.3
1978	33.8	20.8	25.7	32.2	6.6	44.8
1979	34.6	23.2	26.7	34.4	7.7	46.4
1980	35.5	26.3	28.0	36.9	8.9	48.0
III. Regulatory Status Quo						
1972	26.3	9.8	19.2	23.3	4.0	33.6
1973	29.6	12.7	22.1	24.3	2.3	36.7
1974	32.4	13.8	23.0	25.6	2.5	38.9
1975	35.1	15.2	23.9	26.9	2.9	41.2
1976	37.8	17.1	24.9	28.3	3.4	43.7
1977	40.6	19.4	26.0	29.9	3.9	46.2
1978	43.3	22.1	27.2	31.6	4.4	48.9
1979	45.9	25.4	28.6	33.4	4.8	51.7
1980	48.5	29.2	30.2	35.5	5.3	54.6

Source: MacAvoy and Pindyck, 1973, Tables 4, 5, and 6.

Table 8-11 Total associated-dissolved natural gas production possibilities

(Production in Trillions of Cubic Feet per Year)

BAU[1]

Minimum Acceptable Oil Price[2]	1974	1977	1980	1985
$ 4.00	3.665	3.167	3.546	3.999
$ 7.00	3.665	3.365	4.003	5.824
$11.00	3.665	3.479	4.328	6.633

AD[1]

Minimum Acceptable Oil Price[2]	1974	1977	1980	1985
$ 4.00	3.665	3.327	3.803	5.190
$ 7.00	3.665	3.533	4.424	6.357
$11.00	3.665	3.539	4.553	7.978

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[1] Production projections are given for the Lower 48 States and Alaska

AD = Accelerated Development

BAU = Business As Usual

[2] Minimum acceptable oil price is given in constant 1973 dollars per barrel, inasmuch as associated-dissolved natural gas is produced in conjunction with crude oil.

Source: Federal Energy Administration (FEA), 1974, Project Independence Report - Natural Gas.

Table 8-12 Total non-associated natural gas production possibilities

(Production in Trillions of Cubic Feet per Year)

BAU[1]

Price[2]	1974	1977	1980	1985
@ 40¢ (or less)	16.522	15.222	13.337	9.483
@ 60¢ (or less)	16.670	15.847	16.028	16.655
@ 80¢ (or less)	16.670	16.073	16.389	18.139
@ $1.00 (or less)	16.670	16.075	16.394	18.152
@ $2.00 (or less)	16.670	16.075	16.400	18.172

AD[1]

Price[2]	1974	1977	1980	1985
@ 40¢ (or less)	16.552	15.284	13.652	9.100
@ 60¢ (or less)	16.670	16.029	17.781	19.260
@ 80¢ (or less)	16.670	16.265	18.096	21.344
@ $1.00 (or less)	16.670	16.267	18.103	21.348
@ $2.00 (or less)	16.670	16.267	18.110	21.371

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[1] Production projections are given for the Lower 48 States, Alaska, and for the natural gas from tight reservoirs.

AD = Accelerated Development

BAU = Business As Usual

[2] Prices are given in cents per Mcf (in constant 1973 dollars)

Source: Federal Energy Administration (FEA), 1974, Project Independence Report - Natural Gas.

gas production to 1985 are compared to those of the National Gas Survey Case II supply projections.

An analysis of the environmental impact of the proposed deregulation of the wellhead price of gas has been prepared by the Department of the Interior in its final environmental impact statement, "Proposed Deregulation of Natural Gas Prices," June, 1974. As reported in the statement, this alternative would not result directly in any specific action. It would, however, trigger market forces which would result in increased activities impacting on the environment. These activities would center on increased domestic production, both onshore and offshore, of natural gas and associated oil. More detailed discussions of the impact of these activities are contained both in the 1974 environmental impact statement on the proposed deregulation and in the sections on environmental impact of domestic natural gas, which follows, and of domestic petroleum, which appears later in this volume.

8-C-4. Environmental Impact

The environmental residuals added to the air by extracting, gathering, and processing additional supplies of natural gas in the conterminous United States are easy to calculate. Replacement of anticipated gas deliveries (of 4.5 Bcfd) under the Alaska Natural Gas Transportation System in the year 1985 would result in residuals including particles, nitrogen oxides, sulfur oxides, hydrocarbons, carbon monoxide, and aldehydes and amounting to:

(Tons per year)

Particulates	NO_x	SO_x	Hydrocarbons	CO	Aldehydes
534	7,712	18	3,085	12	294

Calculations are based on a method developed by Hittman Associates that is described in a University of Oklahoma Report (1975).

Offshore, there are several significant considerations in siting well and production facilities. Examples are possible effects on commercial fishing, navigation, long-term ecosystem equilibrium, and esthetics. The debris resulting from initial construction and the drilling muds, waters, sand, and chemical wastes associated with drilling and processing facilities remain possible residuals. Present Federal regulations reflect these concerns in requiring that discharged sand must be free of oil and discharged water must have an average of not more than 50 parts per million (ppm) of oil. On land, and in marshes and estuaries, site preparation should include an analysis of the cutting and filling needed for the site, access roads, and other support activities. Details on offshore environmental impacts may be found in two environmental impact statements on the Outer Continental Shelf and Southern California (U.S. Dept. Interior, BLM, 1975a, 1975b).

No water contaminants are generated by any of the modes of gas extraction, gathering, or processing, but thermal pollution may result from operation of natural gas and sulfur extraction plants. The thermal discharge for the natural gas liquids plant is considered to be 25 percent of the energy content of the gas used for plant fuel or 7.7×10^9 Btu's discharged for each 10^{12} Btu's of natural gas processed. For sulfur removal, estimates of the thermal discharge (0.8×10^9 Btu's per 10^{12} Btu's) is based on a plant design to treat 60 million cubic feet per day (MMcfd) of gas containing one grain of hydrogen sulfide (H_2S) per standard cubic foot of gas. If a cooling tower is used, the thermal discharge to water from either type of plant is eliminated.

The magnitude of the gas discharged into the atmosphere during extraction is based on a physical loss estimate of 4.1 percent of the production or 910 tons of hydrocarbons per 10^{12} Btu's of natural gas extracted. In the Hittman analysis (Univ. Oklahoma, 1975) no other residuals are considered to be applicable during extraction.

The estimated NO_x (oxides of nitrogen) emission level during gathering (2.6 tons per 10^{12} Btu's gathered) is obtained from the consumption of 3.67 percent of the produced fuel in gas engines used to drive compressors. No other air pollutants are reported by Hittman for gas gathering.

Emissions from natural gas liquid separation and sulfur removal plants come primarily from the industrial steam generation boilers. In natural gas liquids plants, air emissions total about two tons per 10^{12} Btu's processed; these residuals are based on using 3.1 percent of the gas processed as plant fuel and flaring 0.1 percent. Similarly, the residuals for sulfur removal are small, totaling 0.06 tons, and are based on using natural gas as fuel to generate process steam for a 60-MMcfd plant. On the basis of generation of 6,000 pounds per hour at 40 pounds per square inch atmosphere (psia) steam and 75 percent combustion efficiency, the fuel required is 0.2 MMcfd. No solids are generated in the extracting, gathering, or processing of natural gas.

The environmental impact of enlarged and new processing areas has not been included. Further, the impact of any new pipeline construction has not been considered. Both are related to the source of potential new discoveries of gas. They are not so readily considered as total discharge into the atmosphere. There would be less impact on the physical environment than would be expected with drilling and pipeline construction in new areas, as some increased production would come from established areas. Increased production of natural gas in the conterminous United States would bring with it a significant impact on the environment which is related to the local geography where it might take place. This cannot be estimated with any firmness at this time.

8-D. Alternative Imported Natural Gas Supply Systems

Domestic supplies of natural gas may be supplemented by imports. Currently gas is imported by pipeline from Mexico and Canada. Importation by LNG (liquid natural gas) tanker allows gas to be brought from other parts of the world. This imported gas section is based largely on information taken from the "National Gas Survey, Vol. I, The Commission Report" (FPC, 1975b), and provided by the Office of Economics of the Federal Power Commission.

8-D-1. Natural Gas Resource Base--Mexico

Mexico's natural gas resource base is relatively small when compared to its neighbors to the north. At the end of 1973 Mexico's proved gas reserves were estimated to be approximately 10.8 Tcf, equivalent to about 4 percent of U.S. and 20 percent of Canadian proved reserves. Over the past 10 years, reserve additions have kept pace with production, and resulted in little change for the proved reserve inventory.

The natural gas potential is estimated to be about 85 Tcf, about 11 percent of the potential gas reserves of the Lower 48 States as estimated by the Potential Gas Committee (PGC).

The known oil and gas fields of Mexico are located in four areas along the Gulf Coast side of the country: Northeastern Mexico, the Tampico Embayment, the Poza Rica District, and the Saline and Macuspana-Campeche Basins. The only significant imports of natural gas to the U.S. from Mexico come from the Northeastern area. During 1972, 51 exploratory wells were drilled in this area. This resulted in four new gas field discoveries and four deeper pool gas discoveries and one extension to a previously discovered gas reservoir.

Pipeline Imports--Mexico

The exchange of gas across the Mexican and U.S. boundary was of a local nature until 1957, when the first import certificate was granted to an interstate pipeline company. From 1958 to 1969, imports from Mexico averaged approximately 50 Bcf per year. Since then imports have declined. They were 1.6 Bcf in 1973, as compared to exports to Mexico of about 13 Bcf. The resulting net exports were equal to less than one-tenth of 1 percent of the gas consumed in this country during 1973.

The small volume of gas which is currently imported from Mexico, and the relatively small natural gas resource base of that country, make it seem that Mexico will not be a major source of future pipeline imports. Additionally, Mexico has had a long-standing policy of "self sufficiency in energy." Under this policy it has not been Mexico's aim to develop oil and gas reserves for export. For these reasons, no projections of future natural gas pipeline imports from Mexico were made.

8-D-2. Natural Gas Resource Base--Canada

Canada's ultimate-potential supply (Table 8-13) includes both the discovered supply (cumulative production and proved reserves) and potential resources. Potential resources include undiscovered gas supplies, and those supplies which have been discovered, but were not considered to be within economic reach by the National Energy Board (NEB). Examples of the latter category are the reported discoveries in the Beaufort Sea-Mackenzie Delta, Arctic Islands, and the Atlantic Offshore areas (Figure 8-9).

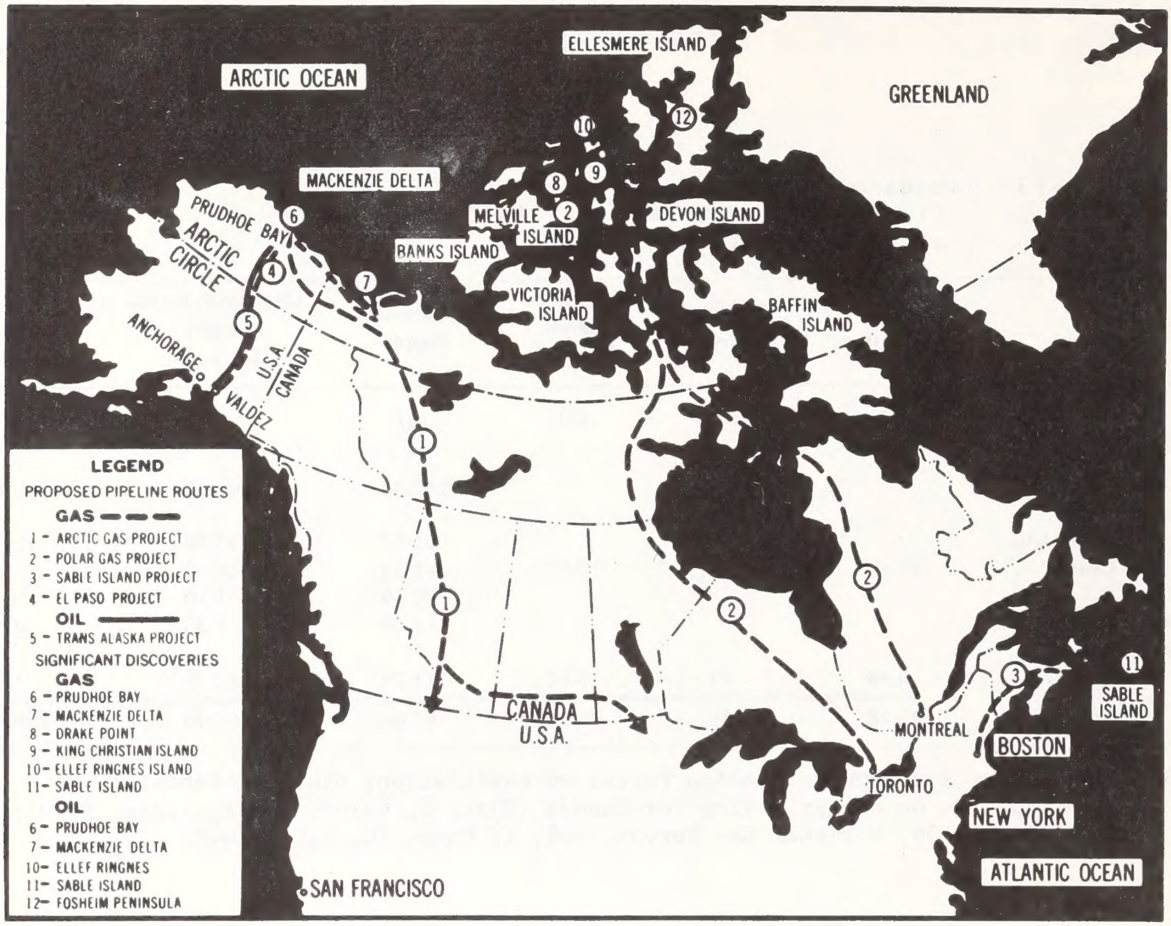
Canada's proved reserves are important when making future import projections because the NEB measures gas requirements against proved reserves to determine whether surplus gas is available for export, and because about 15 Tcf of the proved reserves are currently authorized for export to the U.S. over the next 22 years. At the end of 1973 Canada's proved reserves were estimated at about 52.2 Tcf. This is approximately equal to 21 percent of U.S. domestic reserves, including Alaska, and is less than twice as large as U.S. Alaskan reserves. Proved reserves in Canada declined 2.5 Tcf in 1972 and 0.4 Tcf in 1973. Over 99 percent of the proved reserves are in Canada's so-called traditional gas and oil provinces of western Canada, with the remainder in the Eastern Canadian Onshore area.

Although Canadian proved reserves approximately tripled since 1956, natural gas production has increased tenfold. This resulted in a rapid decrease in the R/P (reserve/production) ratio. It was almost 90 in 1956, and had declined to 22.6 by year-end 1973. During the past year natural gas production in Canada amounted to approximately 2.3 Tcf, of which 1 Tcf, or about 40 percent, was exported to the U.S.

Table 8-13 Canadian natural gas resource estimates (trillion cubic feet at 14.65 Psia and 60°F) as of December 31, 1973

Area	Cumulative Production	Proved Reserves	Discovered Supply (1) + (2)	Potential Supply	Ultimate-Potential Supply (3) + (4)	% of Ultimate Supply
	(1)	(2)	(3)	(4)	(5)	(6)
Arctic Island and North Coastal Plain				242.00	242.00	30.9
Beaufort Sea-Mackenzie Delta .				93.50	93.50	12.0
Western Canada	20.10	52.22	72.32	47.98	120.30	15.4
Atlantic Offshore . . .				307.10	307.10	39.2
Hudson Platform . . .				7.30	7.30	0.9
Eastern Canada Onshore	0.68	.24	0.92	11.78	12.70	1.6
Total	20.78	52.46	73.24	709.66	782.90	100.0

Source: Discovered Supply-Canadian Petroleum Association; Ultimate-Potential Supply - An Energy Policy for Canada (Phase I, Volume I - Analysis, 1973); FPC, 1975b, National Gas Survey, Vol. I, Chap. 10, Table 10-9.



Source: FPC, 1975b, National Gas Survey, Vol. I, Figure 10-2.

Figure 8-9 Proposed pipelines and significant oil and gas discoveries in Canada

The Geological Survey of Canada (GSC) recently began a program to estimate Canadian oil and gas potential on an annual basis. These estimates are based on a geological analysis of all the sedimentary basins in Canada. The GSC indicates that the estimates may change considerably from year to year. This change is based on exploration results as well as an increased insight into geological relationships and petroleum history.

The first and second GSC estimates of Çanada's ultimate-potential oil and gas resources were submitted to the Canadian Minister of Energy, Mines and Resources in February 1972 and March 1973. The second estimate is more detailed and is about 12 percent lower than the first. GSC's second estimate of Canada's ultimate-potential gas supply (includes both discovered and undiscovered supplies) is listed in column 5 of Table 8-13. Column 4 lists the estimated undiscovered potential by area. The GSC defines this potential as "the total gas that might be produced by conventional means without any technological or economic constraints." This estimate of 710 Tcf, for Canada's undiscovered gas resources, is 10 percent less than the Potential Gas Committee potential supply estimate of 780 Tcf in the Lower 48 States.

The estimated undiscovered potential should be of adequate volume to support growing Canadian requirements as well as increased exports to the U.S. However, approximately 82 percent of the potential supply is expected to be found in the remote, high-cost "frontier" areas. As of year-end 1973, none of Canada's reported proved reserves was located in these areas. Although several oil and gas discoveries have been announced here, the reserves have not been developed sufficiently to be considered within economic reach by the NEB. Western Canada, which contains almost 99 percent of the Canadian developed gas supply, is estimated to contain only 15.4 percent of the ultimate-potential supply. Less than 3 percent is assigned to the other producing area, Eastern Canada Onshore.

Table 8-14 compares the GSC 1973 estimate of Canada's ultimate-potential gas supply with other recent estimates.

Pipeline Imports--Canada

Projections of future pipeline imports from Canada for 1973 to 1990 were prepared by the FPC in the National Gas Survey of 1975. These projections can be assumed to be net imports because U.S. natural gas pipeline exports to Canada are relatively small and are not expected to grow significantly.

Case I represents the minimal case for natural gas pipeline imports from Canada. These are the volumes scheduled for export from Canada to the U.S. under currently existing Canadian National Energy Board (NEB) and FPC authorizations. This case assumes that there will not be any additional export authorizations granted through 1990.

The Federal Power Commission's projections for more optimistic Cases (II-IV) range from 1.2 Tcf in 1975 to 3.7 Tcf in 1990 (Case IV). However, all of these estimates include the gas that would be transported by the proposed Alaska Natural Gas Transportation System. Expectations of large quantities of gas being made available to the United States from Canada are now considered to be questionable. Canada's potential reserves are currently being reassessed and it is estimated that the only areas of Canada to provide future gas reserves of a magnitude appropriate to U.S. needs are north of the Arctic Circle. Access to the latter gas could create problems of American delivery systems under Canadian political control.

Table 8-14 Comparison of Canadian ultimate-potential gas supply estimates by region 1/ (trillion cubic feet at 14.65 Psia and 60°F)

Region	Canadian Petroleum Association 1969	Geological Survey Of Canada 1972	Geological Survey Of Canada 1973	Canadian Society of Petroleum Geologists 1973
Arctic Islands & North Coastal Plain	260.70	327.40	242.00	208.08
Beaufort Sea-Mackenzie Delta	283.80	117.20	93.50	64.00
Western Canada		207.40	120.30	155.50
Atlantic Offshore	149.90	229.60	307.10	132.60
Hudson Platform	17.40	8.70	7.30	[2]
Eastern Canada Onshore	13.00	15.80	12.70	16.60
Total	724.80	906.20	782.90	577.50

[1] Includes all gas found to date of estimates.

[2] Potential for Hudson Platform included in Arctic Islands and Coastal Plain (North).

Note: Estimates all have slightly different basis in that areas considered, limit of depths of sediments or depth of water on continental margins are not the same in every case and the CPA estimate includes natural gas liquids, whereas the other estimates are of pipeline quality gas.

Adapted From: Undiscovered Resources, An Energy Policy for Canada (Phase I, Volume II—Analysis, 1973, Table 3, p. 91).

Source: FPC, 1975b, National Gas Survey, Vol. I, Chap. 10, Table 10-10

The most critical economic and technological constraints to additional imports of natural gas from Canada will be the determination of whether Canadian gas exists in excess of their requirements. At the present time this is done in two stages. The first stage is the current gas surplus determination. The National Energy Board (NEB) of Canada requires a proved gas reserve production level of almost 30 times Canada's current gas requirements (including previously authorized export requirements). If the proved reserves exceed the required production level, then a current surplus is declared.

If the current surplus is determined to be of sufficient magnitude, then the NEB may choose to enter into the second stage of the surplus determination. This involves projecting both supply and requirements 20 years into the future. At that point, if supply is in excess of approximately 30 times the requirements, a future surplus is declared. If the NEB considers both the current and future surpluses to be of sufficient magnitude, then they may authorize additional exports.

The following are some of the major factors, or constraints, that may affect the magnitude of future gas imports from Canada: (1) rate of growth of Canada's future gas requirements, (2) location and rate of development of new gas supplies, (3) expenditures for exploration and development of new gas supplies, (4) cost of large-diameter pipelines from remote frontier areas, (5) availability of capital to finance exploration and development and pipeline construction, (6) regulatory and possible legal delays due to court orders, (7) completion of the Trans-Alaska oil pipeline, and (8) ultimate price of the gas at the market place.

In 1973, about 69 percent of the gas imported from Canada was delivered to the west coast areas. Slightly over half of this amount was consumed in California, with the remainder going to markets in Oregon and Washington. The Great Lakes marketing area was the next largest consumer of Canadian gas, using about 26 percent of the imports. About 5 percent of the imports was delivered to Montana with less than 1 percent consumed in New York and Vermont.

Future imports from Alberta, which are in addition to those currently authorized, will probably follow the established distribution pattern. Gas from the Canadian Atlantic Offshore area will be imported into the New England States. A gas pipeline from the Arctic Islands, depending on the route, could deliver gas directly to the Northeastern states, or make gas available for the west coast and Great Lake areas by displacement.

Although the regional pattern of future Canadian gas imports will probably follow the established distribution pattern, with the possible exception of imports from the Arctic Islands and the Atlantic Offshore areas, the proportion of future imports coming into the different regions could change considerably from the current distribution. This will depend on the completion schedule of the various proposed pipeline projects and the prevailing regional demand for the Canadian gas.

The financial requirements of future pipeline imports of natural gas from Canada will be large. Any significant increase in the present level of imports will depend on the development of the frontier area supplies, and the construction of expensive long distance pipelines.

Pipelines from the Arctic Islands and the Canadian Atlantic Offshore areas will be expensive. Any gas pipeline from the Arctic Islands will be at least as expensive as the proposed line from the Alaskan North Slope. Because of technical problems involved in constructing a line between the Arctic Islands, the ultimate cost of the pipeline could be greater than the one for the North Slope-Mackenzie Delta. Although construction of a pipeline from the Sable Island area would not be as expensive as the other two proposed lines, it would nevertheless be a major project. The estimated construction cost of the three proposed pipelines will probably be between $10 and $20 billion. An early completion of any, or all, of the proposed lines could greatly affect their ultimate cost because of inflationary trends. Any expansion of the proposed lines' transmission capacity, after their completion, would raise capital costs.

The capital cost of finding and developing the frontier area gas supplies also will be large. In 1971 the cost of drilling an onshore exploratory well in the Canadian Arctic was about $1 million. Offshore drilling, which will follow the onshore development because many of the prospective areas lie between the islands, will be more expensive. The cost of an exploratory well in the Canadian Atlantic Offshore area is about $1.6 million. Presently, it is impossible to estimate the total number of wells that will be required to justify construction of the proposed lines. The wells must produce sufficient quantities of gas to allow the pipelines to operate at capacity over an extended period of time. It is reasonable to believe that the required capital expenditures will be in billions of dollars over the next 20 years.

The availability of capital which is necessary for the development of Canadian resources, is of concern to the Canadian government. The cost of developing Canada's oil, gas, uranium, electricity and coal resources is estimated to be about $50 billion over the next decade, in addition to the required financing of the proposed pipelines. Of this amount about half will be spent on the development of oil and gas resources. These estimated capital expenditures do not include the cost of any of the three proposed pipelines from the frontier areas.

Companies operating in the Canadian Arctic and Atlantic Offshore regions demonstrated the technological feasibility of drilling oil and gas wells in these areas, and for constructing large-diameter, long-distance gas pipelines. Additional research was conducted for several years by Canadian Arctic Gas Study Ltd. to examine the engineering and environmental aspects of the Alaska Natural Gas Transportation System.

There seem to be no great technological problems in constructing a pipeline from the Atlantic Offshore area to the mainland.

The difficulties which might be encountered by the Alaska Natural Gas Transportation System project in Northern Alaska and Canada would also be encountered in the construction of an Arctic Islands line, and likely there might be additional difficulties. One of the major problems would be the construction of the pipeline gathering system between the islands. Both strong ocean currents and deep scouring of the ocean floor by ice exist in some areas. Presently research is being conducted in regard to the profile of the ocean floor, the thickness of bottom sediments, ice types, ice thickness and ice movements.

During 1972, 10 domestic transmission companies paid an average of approximately 31¢/Mcf for imported Canadian gas. Although the cost of future gas imports cannot be determined precisely at this time, they will be more expensive than current imports from Canada. Any additional exports authorized by the NEB will probably come from Canada's frontier areas. This in itself means more expensive gas because of the cost of transporting the gas over long distances.

8-D-3. Liquified Natural Gas (LNG) Resource Base

The following countries are considered potential sources for LNG supplies (FPC, 1975b, National Gas Survey, Vol. 1, p. 326):

- Algeria
- Australia
- Abu Dhabi
- Brunei
- Ecuador
- Gabon
- Indonesia
- Iran
- Iraq
- Kuwait
- Libya
- Malaysia
- New Zealand
- Nigeria
- Pakistan
- Papua
- Qatar
- Saudi Arabia
- Trinidad and Tobago
- U.S.S.R.
- Venezuela

Total estimated proved gas reserves at year-end 1971 for these countries were 1,163.2 Tcf, while total 1970 production was only 13.6 Tcf. The total foreign gas reserves which are required for forecasted LNG imports are tabulated below. They range from 1.1 percent (Case I) to 12.2 percent (Case IV) of the 1971 gas reserves of the above listed countries. Furthermore, 1970 gas consumption for these countries was 8.6 Tcf, some 5 Tcf less than production; considerable amounts of gas are probably flared or vented when oil is produced. It is expected, therefore, that foreign gas reserves will not limit the projected levels of LNG imports.

Foreign Gas Reserves for LNG Imports
(trillions of cubic feet)

(In increment required by each cardinal year)

	1975	1980	1985	1990	Total
Case I	0.5	12.7	-	-	13.2
Case II	2.0	47.4	-	-	49.4
Case III	12.3	76.4	36.0	-	112.4
Case IV	12.3	94.4	18.0	30.0	142.4

Source: FPC, 1975b, National Gas Survey, Vol. 1, Chap. 10, Table 10-17.

LNG Imports

The future United States gas supply will include imported liquefied natural gas (LNG) from regions that have large gas reserves but limited internal markets. LNG imports in 1973 totalled 4.1 Bcf of which 83 percent originated from Algerian gas and 17 percent from Canadian gas (see Table 8-15). An indication of future LNG prospective imports can be obtained by reviewing the projects filed with the Federal Power Commission (Table 8-16), and prospective projects discussed in the trade press (Table 8-17).

Four cases of LNG imports to the conterminous United States are projected for 1975 through 1990 by the National Gas Survey, and are shown in Table 8-18. Case I, the lowest case, is based on the assumption that only those projects which are presently approved by the FPC will reach completion. Case IV, the highest case, is based on the assumption that all of the projects shown, or mentioned on Tables 8-16 and 8-17, will reach fruition within the time frame to 1990. Cases II and III are intermediate cases. Case II, the "conservative realistic" case, assumes that only projects which were approved or filed with the FPC will be completed. Case III, "optimistic realistic," includes projects in Cases I and II, as well as projects one through seven on Table 8-17. Case III assumes that there will be more deliveries in 1975, than in Case II, 1975. Projects one through

Table 8-15 Liquefied natural gas (LNG) imports to the United States, 1973 1/

	Companies Importing LNG from Algeria				
	Boston Gas Company	Distrigas Corporation	U.S. Imports from Algeria	U.S. Imports from Canada[2]	Total LNG Imports to the United States
Docket No.	CP73-40	CP70-196			
U. S. Receiving Point	Boston, Mass.	Everett, Mass.			
Volume Received:					
Barrels (42 U.S. Gallons)	95,903	879,706	975,609	192,588	1,168,197
Mcf Equivalent @ 14.73 Psia)	320,576	3,067,734	3,388,310	667,217	4,055,527
MM B.t.u.	366,240	3,274,216	3,640,456	708,293	4,348,749
Average B.t.u. Per Cu. Ft.	1,142	1,067	1,074	1,062	1,072
Cost:					
Total Paid—$	694,795	2,265,757	2,960,552	1,290,454	4,251,006
Average Price—Cents Per MM B.t.u. ..	189.7	69.2	81.3	182.1	97.8
Average Price—Cents Per Mcf	216.7	73.9	87.4	193.4	104.8

[1] Preliminary.

[2] LNG is imported by truck from Canada for Lowell Gas Company, Providence Gas Company and Brockton Taunton Gas Company.

Source: FPC, 1975b, National Gas Survey, Vol. I, Chap. 10, Table 10-12.

Table 8-16 Long term LNG import projects filed with the Federal Power Commission as of November 30, 1973

Source	Importer	FPC Docket No.	Delivery Point	Deliveries[1] (MMcf/day)	Deliveries[1] (Bcf/Yr.)	Time Frame	Status
1. Skikda, Algeria	Distrigas Corp.	CP70-196, CP72-165, CP72-167, CP72-168, CP73-135, CP73-230	Everett, Mass. & Staten Is., N.Y.	42	15	1971 (20 Years)	Approved
2. Arzew, Algeria	Columbia LNG Corp.	CP71-68, CP71-289	Cove Point, Md.	319	116	1976-1977 (25 Years)	Approved
	Consolidated Systems LNG Co.	CP71-153, CP71-289, CP71-290	Cove Point, Md.	372	136		
	Southern Energy Co.	CP71-151, CP71-264	Savannah, Ga.	372	136		
3. Skikda, Algeria	Eascogas LNG. Inc.	CP73-47, CP73-88[2]	Staten Island, N. Y., & Providence, R. I.	326 (year 1-2)	119	1975-1976 (22 years)	Pending
				487 (year 3)	178		
				652 (year 4-20)	238		
				408 (year 21-22)	149		
4. Skikda, Algeria	Distrigas Corp.	CP73-132, CP73-230[3]	Everett, Mass., & Staten Is., N. Y.	123	45	1975 (20 years)	Pending
5. Arzew, Algeria	El Paso Eastern Co.	CP73-258, CP73-259[4]	Gloucester Co., N. J.	422	154	1978 (25 years)	Pending
	Transco Energy Co.	CP73-267, CP73-269	Gloucester Co., N. J.	422	154		
	Southern Energy Co.	CP73-271, CP73-272	Savannah, Ga.	112	41		
	Consolidated System LNG Co.	CP73-283, CP73-284	Cove Point, Md.	169	62		
6. Arzew, Dellys, or Skikda, Algeria	Trunkline LNG Co.	CP74-139[5]	Lake Charles, La.	490	179	1979 (20 years)	Pending
7. NW Sumatra, Indonesia	Pacific Indonesia LNG Co.	CP74-160	Port Hueneme, Calif.	620	226	1979 (20 years)	Pending

[1] 1,000 Btu/cf.

[2] Related Docket Nos.: Algonquin LNG, Inc. CP73-139; Algonquin Gas Transmission Co. CP73-197; New England LNG Co., Inc. CP73-199.

[3] Related Docket No.: Distrigas Pipeline Corp. CP73-148.

[4] Related Docket Nos.: El Paso Natural Gas Co. CP73-260: Transco Terminal Co. CP73-268; Transcontinental Gas Pipeline Corp. CP73-270; Southern Natural Gas Co. CP73-273.

[5] Related Docket Nos.: Trunkline LNG Co. CP74-138; Trunkline Gas Co. CP74-140.

Source: FPC Files, and 1975b, National Gas Survey, Vol. I, Chap. 10, Table 10-13.

Table 8-17 Prospective U.S. long term base load LNG import projects noted in the trade press as of November 1973

Source	Major Proponent	Importer	Delivery Point	Deliveries[1]		Time Frame	Status
				(MMcf/day)	(Bcf/Yr.)		
1. Trinidad . .	Standard Oil Co. of Indiana	Natural Gas Pipeline Co. of America	Corpus Christi, Texas	400	146	1977-1978	Agreement signed; engineering underway
2. Australia .	Pacific Lighting Corp.	Southern California Gas Co.	Southern California	500	183	1978	Agreement reached; reserves to be proven
3. Iran	International Systems and Controls Corp.	a) Northern Illinois Gas Co. b) [2]	East Coast East Coast	200 700	73 256	1976 1977	Agreements signed; reserves to be proven
4. Nigeria . . .	Shell/BP & Nigerian Gov't.	[2]	East Coast	800	292	1977	Advanced negotiation
5. Venezuela	Venezuelan Gov't.	[2]	–	670	245	1976	Gov't to let bids during 1973
6. U.S.S.R. . . (Western)	Texas Eastern Trans. Corp., Tenneco, Inc., Brown & Root, Inc.	[2]	East Coast	2,000	730	1980	Planning-Negotiating
7. U.S.S.R. . . (Eastern)	El Paso Natural Gas Co., Occidental Petroleum Corp., Bechtel Corp.	[2]	West Coast	1,000	365	1980	Planning
8. [3]							

[1] B.t.u. content unknown.

[2] Not available.

[3] Additional LNG projects which have been noted, but about which little information has been published, include Ada Oil Co. (Ecuador), Mobil Oil Corp. (Indonesia), Phillips Petroleum Co. (North Sea-Nigeria).

Source: Various trade journals, newspapers, and technical papers; FPC, 1975b, National Gas Survey, Vol. I, Chap. 10. Table 10-14.

Table 8-18 Projected foreign LNG imports to the conterminous United States 1975, 1980, 1985, 1990 (trillion cubic feet)

	1975	1980	1985	1990
Case I	[1]	.4	.4	.4
Case II	.1	1.5	1.5	1.5
Case III	.4	2.7	3.8	3.8
Case IV	.4	3.2	3.8	4.7

[1] 15 billion cubic feet.

Source: FPC, 1975b, National Gas Survey, Vol. I, Chap. 10, Table 10-15.

seven on Table 8-17 are considered less speculative than the projects mentioned in footnote two, Table 8-17.

Technology for the production and handling of liquefied natural gas (LNG) is well established. The basic benefit of liquefaction is a greater than 600 to one volume reduction advantage when converting from the gaseous to liquid phase; all references to LNG volumes are in terms of cubic feet of gaseous equivalent. This offers a greater degree of flexibility for the transportation and storage of natural gas, which is shown by utility companies' use of LNG in such distribution operations as remote and emergency deliveries, peak shaving, and satellite facilities. However, these activities are only a means of obtaining a more effective distribution of the existing domestic gas supply.

Domestic LNG imports can be divided into two categories, short-term and long-term. Short-term imports are contracted for on a spot basis for delivery over a relatively short period of time, usually for less than a couple of years. They usually depend upon an excess capacity in the existing LNG systems. During 1973, short-term imports were less than 1 Bcf. Approximately two-thirds of the short-term imports arrived by truck from Canada, and about one-third by ship from Algeria. Long-term imports are those that are contracted for on a regular delivery basis, over a relatively long period of time (usually 20 to 25 years) and are generally utilized as supplemental base-load supplies for utilities. During 1973, long-term imports from Algeria were approximately 3.1 Bcf. However, these imports were used as peak shaving supplies. There have been no long-term imports for base-load use to date in the U.S. All 1973 LNG imports are shown on Table 8-15.

Of these two import categories, it is expected that the long-term marine imports will be the most significant. Short-term imports have made significant contributions to the gas supply of specific companies.

A long-term LNG import project is usually designed to deliver about 300 MMcfd on shorter hauls, and up to 1 Bcfd and more, for longer distances. These projects are capital intensive, and require up to $2.0 billion for each Bcfd delivered. There are four general phases in any of these projects: (1) foreign gas reserves, field development, and pipeline facilities, (2) liquefaction plant and shipping terminal, (3) marine transportation, and (4) receiving terminal, regasification plant, and pipeline facilities.

Gas reserves for a project should be sufficient to last from 20 to 25 years. A minimum of 12 Bcf is required for each MMcfd delivered to the point of regasification. This means that a 300 MMcfd project requires at least 3.6 Tcf of reserves, and a 1 Bcfd project requires at least 12 Tcf of reserves.

Development wells must be drilled; and usually field processing equipment is needed. In most cases, gas reserves are located some distance from the liquefaction plant site which is usually on the seacoast. Therefore, transmission facilities are needed.

To liquefy natural gas, refrigeration units are required to reduce the gas temperature to -260°F, at atmospheric pressure. In addition, the incoming gas must be free from impurities which may solidify during the liquefaction process. Once LNG is produced, storage tanks are needed. They are used as a buffer between the continuous liquefaction process and the intermittent ship loading operations. Adequate harbor development and facilities for loading the LNG tankers are also required at the shipping terminal.

Highly specialized ships capable of maintaining LNG at cryogenic temperatures are required for LNG transport. A typical LNG ship has a 120,000 cubic meter (4.2 million cubic feet) capacity, a length of about 875 feet, a beam of about 135 feet; it draws about 38 feet of water, and has a speed of between 18 to 20 knots. The number of ships that are needed for an LNG project is a complex function determined by the desired volume of deliveries, distance between ports, and ship capacities and speed. To deliver 1 Bcfd over a distance of 4,000 nautical miles, about 9 ships with 120,000 cubic meter capacity and 20 knot speed are required.

The receiving terminal facilities are similar to the shipping terminal facilities except that instead of a liquefaction plant a regasification plant is required to reconvert the LNG to a gas by adding heat. Port, offloading, storage, and pipeline facilities are all necessary.

The LNG imports forecast in Table 8-18 assume a favorable U.S. government policy towards LNG imports. There is a possibility that these imports could be effectively legislated against, because of national security and balance of payments implications. These considerations are exemplified by the 1973 embargo on petroleum shipments from Arab countries to the U.S.

The forecasts on Table 8-18 are also based on the assumption that the U.S. will be a successful competitor for world-wide supplies of surplus natural gas. Those projects already on file with the FPC are an indication that the U.S. can compete successfully. However, some of these projects are now undergoing contract renegotiations, particularly as to price.

The major factors which will affect the actual amount of LNG imported during the period to 1990 are: (a) magnitude of the gap between domestic gas supply and total demand, (b) U.S. government policy with respect to LNG imports, (c) ability and willingness of U.S. users to compete successfully with other nations for world-wide natural gas supplies, (d) availability of capital funding, (e) availability of LNG shipbuilding capacity, and (f) amount of surplus world-wide gas reserves.

Environmental Impact

The prime environmental impacts associated with the import of LNG are the safety aspects of the tankers, and terminal operations connected with LNG transfer to the shore storage tanks, gasification, and transfer to pipelines. Hazards associated with uncontrolled release of LNG (spillage) can be summarized as: local chilling by the cryogenic liquid stored at -260°F; fire hazard of inflammable gas air mixtures; and a potential explosive hazard when a large amount of heat is released at a rapid rate by the burning gas.

The hazards associated with tanker transport across the seas consist of the gas boil-off which requires careful safety measures to prevent formation of local flammable mixtures, and uncontrolled spillage in case of a remote but possible event of a tanker running aground or colliding with another vessel or object. The LNG tanks aboard a tanker are of a double wall construction with low conductivity insulation between the walls to reduce the gas boil-off. This type of construction offers some protection against puncture and against external fire exposure. However, if major damage to the tanker should occur causing a massive spillage of LNG, then friction, static electricity, or an electric short could cause an accidental ignition of the gas. The rate of heating and boil-off of the bulk of LNG may then be great enough to exceed the pressure-relieving capacity of the tanks, causing an explosive pressure burst of the tanks and a probable destruction of the tanker and its surrounding.

The detailed step by step hazard assessment from the tanker entering the port to the gas discharged into the pipeline is presented in section 8.2 of the Alternatives volume dealing with the all-Alaska pipeline-LNG tanker-regasification alternative and the FPC draft environmental impact statement (FPC, 1975a). Because hazards are similar with imported LNG, the reader is referred to these reports.

The environmental effects of natural gas imported from Canada by pipeline were examined in the geographic volumes of this environmental impact statement.

8-D-4. References on Natural Gas Systems

Further detailed discussions on alternative domestic and imported natural gas supply systems may be found in the following references, which are cited in full in the list in Section 8-F-12, References, of this volume: Am. Assoc. Petroleum Geologists, 1971; Cram, 1971; Dupree and Corsentino, 1975; FEA, 1975; FEA, Interagency Task Force on Natural Gas, 1974; FPC, 1975a, 1975b; Gillette, 1974; Hendricks, 1965; Hittman Associates, 1974-1975; Hubbert, 1974; Joint Assoc. Survey (JAS), 1971; MacAvoy and Pindyck, 1973; McKelvey, 1974, 1975; Library of Congress, Congressional Research Service, 1974; Miller and others, 1975; National Academy of Sciences, 1975; NPC, Comm. on U.S. Energy Outlook, 1973b; Potential Gas Committee, 1973; Theobald and others, 1972; U.S. Congress, House of Representatives, Comm. Govt. Operations, 1975; U.S. Congress, Senate, Comm. Interior and Insular Affairs, 1974; U.S. Dept. Interior, 1974; U.S. Dept. Interior, BLM, 1975a,b,c; Univ. Oklahoma, 1975, Chap. 4; and Weeks, 1960.

8-E. Alternative Energy Sources

The potential for substitution of projected gas deliveries under the Alaska Natural Gas Transportation System, through a replacement by specific energy sources, is evaluated by calculating replacement in terms of the energy equivalents of the proposed Alaska Natural Gas Transportation System deliveries. The potential for such substitution has been assessed for coal, petroleum, oil shale, synthetic natural gas and oil, hydroelectric power, geothermal energy, and electricity from nuclear power. Various longer-term potential energy sources such as tar sands, hydrogen, biological energy, solar energy, tidal power, and wind power, as well as conversion techniques for more efficient utilization of existing energy sources have also been considered.

Except for the environmental impacts of both domestic and imported natural gas and petroleum, which are discussed in other sections of this Alternatives volume, the most significant environmental impacts of the other five major alternative energy sources (coal and synthetic natural gas, oil shale, nuclear energy, and geothermal energy) are discussed in a later section, "Summary of Environmental Impacts of Alternative Energy Sources." This summary gives a more uniform picture of the most significant impacts of these five energy sources, which, because of variations in their nature and impacts, cannot all be treated in the same manner and with the same emphasis under their individual environmental impact descriptions. Only coal appears to be a realistic energy source, with nuclear energy as a second potential but far less realistic energy source (Bethe, 1976; Guccione, 1975a), to replace the equivalent of Alaska gas within the time frame of the project.

It must be emphasized that any discussion of alternatives in energy is concerned only with the additions to supply that would be needed to replace the energy equivalents of Alaska natural gas which might be transported by the proposed pipeline. It does not include any comment on development of alternative sources planned to replace other fuels or to increase the total amount of energy available. For example, the discussions of the number of strip mines or nuclear power plants calculated to replace the energy equivalents of Alaskan gas do not consider the environmental impact of other plants and mines which are currently being built or are projected. The impact of additional plants and mines may simply be additive but there could be an exponential effect on the environment.

In addition, it is not clear that an alternative fuel can automatically be substituted for natural gas, even though the same energy equivalents are available.

Several long-term energy sources have been discussed in a number of places in recent years; these include tar sands, tidal and wind power, biological energy, and solar energy. Some possible future conversion techniques for energy, such as, magnetohydrodynamics, thermoelectric and thermionic generation, use of fuel cells, and conversion to hydrogen, are also subjects which are increasingly discussed. By the year 2000, one or more of these new developments may begin to enter significantly into the picture of the nation's energy resources, but within the time frame of the proposed Alaska Natural Gas Transportation System, they need not be discussed further here. However, the following references, which are cited in full in the list in Section 8-F-12, References, of this volume, do consider the long-term energy sources and the future conversion techniques. For the long-term energy sources, see Anderson, 1972; Beck, 1975; Cambel, 1964; Duffie and Beckman, 1976; ERDA, 1975; ERDA, Div. Solar Energy, 1975; FPC, Bur. Power, 1973; Gregory, 1973; Hamilton, 1975; Hammond, 1974; Hammond and others, 1973a,b; Heronemus, 1972; Hubbert, 1971; Leverson, 1967; McConville, 1975; Metz, 1973; NPC, Comm. on U.S. Energy Outlook, 1973b; Peterson, 1974; Report of Task Force on Energy Conversion, 1974; Rose, 1974; Shaw, 1975; Smil, 1974; Sørensen, 1975; Summers, 1971; U.S. Congress, House of Representatives, 1974; U.S. Dept. Interior, 1972; U.S. Dept. Interior, BLM, 1973; Univ. Oklahoma, 1975, chap. 5; Wade, 1974; Wolf, 1974; and Zener and Fetkovich, 1975. For future conversion techniques, see Cambel, 1964; FPC, 1971; Hammond and others, 1973c; Heath, 1973; Maugh, 1972; Revesz, 1973; U.S. Atomic Energy Comm., 1974b, vol. 4; U.S. Dept. Interior, 1972; U.S. Dept. Interior, BLM, 1973; and Univ. Oklahoma, 1975, chap. 12.

If coal usage is increased greatly, the potential United States energy supply will exceed probable demand through the year 1990 and beyond. Uranium supply could be limited under present nuclear reactor technology, but may be extended if the breeder reactor technology is successful and licenses are approved for its use. Other key domestic energy resources, particularly natural gas and petroleum, are not as abundant as coal and are in limited supply especially within regions that are major consumers of these resources.

Terminology for reserve and resource estimates in this report generally follows usage recently formulated by the United States Geological Survey and the United States Bureau of Mines. Reserves is restricted to materials that can be extracted economically from deposits of known extent using conventional methods. Resources is used for materials that either have not yet been discovered or occur in deposits for which technology is not yet available. Further explanations of the terms are given in Appendix II.

Some recent estimates of remaining domestic energy resources in the U.S. and Alaska including reserves and identified recoverable resources, are

1,731 billion short tons of coal (Averitt, 1975); 272-454 billion barrels of oil; 1396-2516 Tcf of natural gas; and 2.4 million tons of uranium (in U_3O_8 equivalent recoverable at $30/lb) unadjusted for the impact of the breeder reactor (Table 8-19). Two coal figures in Table 8-19 should be revised to reflect the study by Averitt (1975), which indicates the remaining recoverable resources as 1,731 billion short tons and the proved recoverable reserves as 424 billion short tons. The relative projected demand and percentage would be about the same as shown in the table.

Other methods of calculating resource depletion and longevity of remaining resources result in much lower estimates of remaining potential. For example, one oil company estimate (NAS, 1975) based on these methods predicts undiscovered recoverable resources of 89 billion barrels of oil and 374 Tcf of natural gas, compared to the U.S. Geological Survey's low range estimates of 50 billion barrels and 322 Tcf (Miller and others, 1975). Using the Geological Survey's low range estimates, without adjustment for non-recoverable portions of the energy resource base, at a rate of gas consumption of 0.75, remaining recoverable resources would be completely consumed in 36 years, assuming no imports. Domestic supplies of low-cost uranium U_3O_8 in the United States are estimated to last 25 years under the technology of present-day reactors (Table 8-19). Apparently there is enough coal in the United States to last 155 years at a projected rate of consumption increase of 2.9 percent per year.

8-E-1. Coal

Resource Base

Coal is the most abundant fossil fuel in the Nation, and consideration must be given to its use as an alternative to gas from Alaska. Coal-based synthetic gas is discussed in a later section. Total coal resources in the United States are about 5,800 times annual production.

The United States is a major coal exporter (Table 8-20). Relatively small amounts of coal are imported into the United States, with only 47,000 tons of imports reported in 1972 and 200,000 tons in 1973; because of lower mining costs and the abundance of coal resources in the United States, the coal import market in the United States has been insignificant in the past. In contrast, 53 million tons were exported in 1973 and an estimated 59-61 million tons in 1974. Because of the needs for electric power generation, there have been proposals to prohibit future exports of coal. Coal exports currently amount to about 9 percent of domestic production of bituminous coal. In 1973, about 77 percent of the coal exported consisted of high grade metallurgical coking coal, and about 23 percent was steam coal used for electrical power generation. Most of the steam coal goes to Canada, where a portion is used in connection with the U.S.-Canadian power intertie.

Domestic coal producing costs and prices have dramatically increased during the past year, and environmental restraints prohibit use of much of this domestic coal. Nevertheless, foreign coal is not considered a viable alternative; it is unlikely that foreign coal acceptable to domestic environmental standards or sufficiently low in cost could be imported to replace the energy to be provided by the proposed Arctic Gas pipeline system.

The total coal resource base in the United States is estimated at about 3,968 billion tons (Averitt, 1975). Of this total, 1,731 billion tons are considered to be remaining identified resources that could be made available under certain conditions (Table 8-21). The portion of the resource base classified as measured reserves is 184 billion tons (Table 8-21). Measured

Table 8-19 Domestic supply and demand relationships

Supply[1]	Natural gas (Tcf)	Petroleum[2] (billion bbls)	Coal (billion tons)[3]	Uranium (U_3O_8) (thousand tons)[3]	Total (Q Btu)[4]
Remaining recoverable resources . .	2,516	494	1,577	2,400	37.8
Proved recoverable reserves	250	36	184	273	4.7
percent share[5]	9	7	12	11	12
Projected demand:					
1971-1990[6]	468	141	12.8	512	1.9
percent increase[7]	1.3	3.1	3.1	24.0	3.8

[1] From Tables 6-3 through 6-8

[2] Includes Natural Gas Liquids

[3] Short Tons.

[4] Quintillion Btu.

[5] Proved recoverable reserves as a percent of remaining recoverable resources

[6] Tables 6-10 through 6-15. (Accumulative 1971-1990)

[7] Average Annual Increase

Prepared by: Office of Economics, Federal Power Commission

Source: FPC, 1975b, National Gas Survey, Vol. I, Chap. 6, Table 6-2 and tables cited above.

Table 8-20 U.S. net trade,1/ mineral fuels

Mineral fuels	Exports Quantity 2/	Imports Quantity 2/	Net Trade Quantity 2/	Percentage Change from 1972
Anthracite:				
1972-------------------------	**-1,191.0**	-	-1,191.0	
1973 (preliminary)------------	-1,000.0	-	-1,000.0	-16.0
1974	NA	NA	NA	NA
Bituminous coal and lignite:				
1972-------------------------	-55,960.0	47.0	-55,913.0	
1973 (preliminary)------------	-53,000.0	200.0	-52,800.0	- 7.4
1974 (estimated)	59,000-61,000	NA	59,000-61,000	+ 11% + 16%
Natural Gas, dry 3/:				
1972--------------------------	-78,013	1,019,496	941.483.0	
1973 (preliminary)------------	-80,000	1,030,000	950,000.0	+0.9
1974 (estimated)--------------	NA	NA	NA	
Petroleum (crude): 4/				
1972--------------------------	-0.2	811.1	810.9	
1973 (preliminary)------------	-0.5	1,184.4	1,184.9	+45.3
1974 (estimated)	-1.0	1,249.0	1,248.0	+ 5.4
Petroleum products: 4/				
1972--------------------------	-81.2	924.2	843.0	
1973 (preliminary)------------	-84.7	1,065.9	981.2	+16.4
1974 (estimated)	-80.3	1,020.0	1,939.7	-4.3
Total mineral fuels:				
1972--------------------------	NA	NA	NA	
1973 (preliminary)------------	NA	NA	NA	+33.1
1974	NA	NA	NA	NA

1/ Minus sign indicates exports.
2/ Quantities used are: Anthracite and bituminous coal and lignite, thousand short tons; natural gas, million cubic feet; and petroleum (crude and products), million barrels.
3/ Excludes natural gas liquids.
4/ Includes natural gas liquids.
XX Not applicable.

Source: Division of Fossil Fuels-Mineral Supply, Bureau of Mines, U.S. Department of the Interior, News Release March 13, 1974 and preliminary estimates for 1974 based on 10 months data.

Table 8-21 Estimated United States supply function for coal (including bituminous, subbituminous, lignite, anthracite)

	Million short tons	Quadrillion Btu
Remaining Identified Resources:[1]		
Total all ranks	1,577,000	31,124
Low sulfur 0-1 percent	1,022,000	17,854
Medium sulfur 1.1-3 percent	240,000	5,451
High sulfur > 3 percent	315,000	7,819
Anthracite	15,000	381
Bituminous	725,000	18,037
Subbituminous	389,000	6,613
Lignite	448,000	6,093
Proved Recoverable Reserves:[2]		
Total all ranks	184,000	4,054
Anthracite	1,000	234
Bituminous and subbituminous	155,000	3,436
Lignite	28,000	384

[1] Remaining identified resources that could be made available under certain technical and economic conditions. For coal this represents the total resource base reduced by a recovery factor of 50 percent. Estimates of sulfur content are based on calculations of the sulfur content of the total resource base and components.

[2] Measured reserves recoverable under existing economic and operating conditons.

Sources: *Energy Resources of the United States,* U.S. Geological Survey Circular 650, U.S. Geological Survey, Washington, D.C., 1972; *Coal Resources of the United States,* U.S. Geological Survey Bulletin 1275, Washington, D.C., 1967; U.S. Department of the Interior, Bureau of Mines, *Commodity Data Summaries,* 1974; Interagency Coal Task Force, Reserve Base Preliminary Data, 1974. FPC, 1975b, National Gas Survey, Vol., Chap. 6, Table 6-6.

Prepared by: Office of Economics, Federal Power Commission.

and indicated reserves total about 434 billion tons according to Bureau of Mines data (Table 8-22) taken from Averitt (1975). Definitions of resource terms are given in Appendix II.

The distribution of the United States underground and surface coal reserves by states is shown in Table 8-22 and Figure 8-10. Of the total recoverable reserves, about 68 percent can be obtained by underground mining methods, and 32 percent by surface mining. Annual coal production in the United States typically ranges from 500 to 600 million tons. However, no excess capacity exists and additional production must come from new mines.

The nation's major coal resources are in three large areas: Appalachia, the Midwest, and the West (Figure 8-10). In all regions, coal varies in its sulfur content. The predominant quantities of low sulfur coal, are in the southern Appalachian region and the northern Rockies. The quantities of coal reserves are shown in Table 8-23. Much of the low sulfur, high quality coals in Appalachia are committed to the metallurgical industry. Midwestern coal is high in sulfur content; its use would be unacceptable in many parts of the United States without air pollution control equipment. There is an abundant supply of low-sulfur bituminous and subbituminous coal and lignite in the Rocky Mountain States (Thurlow, 1974) that possibly could be utilized as a substitute for the Alaskan gas.

Incremental Production

The estimated gas supplies that could be made available by the Alaska Natural Gas Transportation System are 2.25 Bcfd for Alaskan gas only or 4.5 Bcfd for Alaskan and Canadian gas combined. These amounts would have to be replaced by the Btu equivalence in increased production of coal, if coal is to serve as an alternative energy source. Coals vary widely in heat content ranging from 730 Btu/lb for lignite to 15,600 Btu/lb for low-volatile bituminous coal. Estimates of the amounts of coal needed to replace a maximum of 4.5 Bcfd of Arctic gas based on a heat content of 11,875 Btu/lb are tabulated below.

Year	Alaska and Canadian Arctic	Los Angeles and San Francisco (maximum capacity)	Northern Border (maximum capacity)
	(million short tons of coal per year)		
1975	-	-	-
1980	55	19	19
1985	71	38	55
1990	71	38	55

The reserves of coal in the United States are adequate to replace the energy that would be transported by the Alaska Natural Gas Transportation System. The most likely source area for coal to replace the Arctic gas would be the Rocky Mountain States because of this coal's low sulfur content. The assumption is made that replacement of energy from the Alaska Natural Gas Transportation System to the west coast by coal from the Rocky Mountain area is more probable than replacement of this energy to the Northern Border pipeline because of the shorter transportation distance.

Table 8-22 Coal reserve base of the United States, January 1, 1974, by State and by method of mining

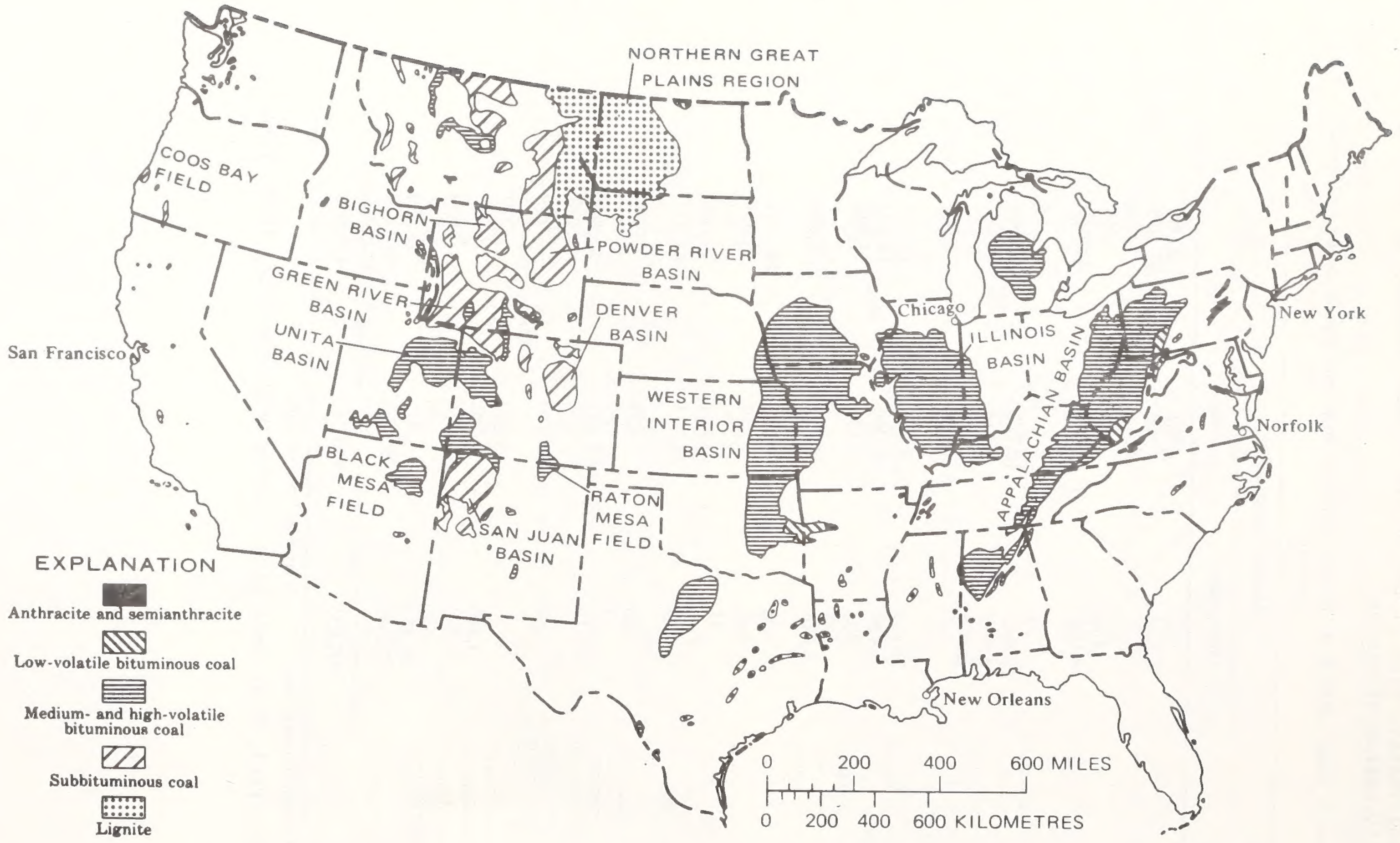
[Data from U.S. Bureau of Mines (1974b, p. 4). In millions (10^6) of short tons. Figures are for coal in the ground]

State	Potential mining method		Total
	Underground	Surface	
Alabama	1,798	1,184	2,982
Alaska	4,246	7,399	11,645
Arizona	(1)	350	350
Arkansas	402	263	665
Colorado	14,000	870	14,870
Georgia	1	....	1
Illinois	53,442	12,223	65,665
Indiana	8,949	1,674	10,623
Iowa	2,885	(1)	2,885
Kansas	(1)	1,388	1,388
Kentucky, eastern	9,467	3,450	12,917
Kentucky, western	8,720	3,904	12,624
Maryland	902	146	1,048
Michigan	118	1	119
Missouri	6,074	3,414	9,488
Montana	65,165	42,562	107,727
New Mexico	2,136	2,258	4,394
North Carolina	31	(2)	31
North Dakota	....	16,003	16,003
Ohio	17,423	3,654	21,077
Oklahoma	860	434	1,294
Oregon	1	(2)	1
Pennsylvania	29,819	1,181	31,000
South Dakota	....	428	428
Tennessee	667	320	987
Texas	....	3,272	3,272
Utah	3,780	262	4,042
Virginia	2,971	679	3,650
Washington	1,446	508	1,954
West Virginia	34,378	5,212	39,590
Wyoming	27,554	23,674	51,228
Total	297,235	136,713	433,948

[1] Data insufficient to establish reserve base.

[2] Less than 1 million tons.

Source: Averitt, Paul, U.S. Geological Survey Bulletin 1412, 1975, Table 5.



Source: Averitt, Paul, U.S. Geological Survey Bulletin 1412, 1975, Figure 1

Figure 8-10 Coal fields of the conterminous United States

Table 8-23 Total estimated remaining coal resources of the United States, January 1, 1974

[In millions (10^6) of short tons. Estimates include beds of bituminous coal and anthracite generally 14 in. or more thick, and beds of subbituminous coal and lignite generally 2½ ft or more thick, to overburden depths of 3,000 and 6,000 ft. Figures are for resources in the ground]

State	Overburden 0–3,000 feet							Overburden 3,000–6,000 feet	Overburden 0–6,000 feet
	Remaining identified resources, Jan. 1, 1974 (from table 2)					Estimated hypothetical resources in unmapped and unexplored areas[1]	Estimated total identified and hypothetical resources remaining in the ground	Estimated additional hypothetical resources in deeper structural basins[1]	Estimated total identified and hypothetical resources remaining in the ground
	Bituminous coal	Subbituminous coal	Lignite	Anthracite and semi-anthracite	Total				
Alabama	13,262	0	2,000	0	15,262	20,000	35,262	6,000	41,262
Alaska	19,413	110,666	(2)	(3)	130,079	130,000	260,079	5,000	265,079
Arizona	[4]21,234	(4)	0	0	21,234	0	21,234	0	21,234
Arkansas	1,638	0	350	428	2,416	[5]4,000	6,416	0	6,416
Colorado	109,117	19,733	20	78	128,948	161,272	290,220	143,991	434,211
Georgia	24	0	0	0	24	60	84	0	84
Illinois	146,001	0	0	0	146,001	100,000	246,001	0	246,001
Indiana	32,868	0	0	0	32,868	22,000	54,868	0	54,868
Iowa	6,505	0	0	0	6,505	14,000	20,505	0	20,505
Kansas	18,668	0	(6)	0	18,668	4,000	22,668	0	22,668
Kentucky:									
Eastern	28,226	0	0	0	28,226	24,000	52,226	0	52,226
Western	36,120	0	0	0	36,120	28,000	64,120	0	64,120
Maryland	1,152	0	0	0	1,152	400	1,552	0	1,552
Michigan	205	0	0	0	205	500	705	0	705
Missouri	31,184	0	0	0	31,184	17,489	48,673	0	48,673
Montana	2,299	176,819	112,521	0	291,639	180,000	471,639	0	471,639
New Mexico	10,748	50,639	0	4	61,391	[7]65,556	126,947	74,000	200,947
North Carolina	110	0	0	0	110	20	130	5	135
North Dakota	0	0	350,602	0	350,602	180,000	530,602	0	530,602
Ohio	41,166	0	0	0	41,166	6,152	47,318	0	47,318
Oklahoma	7,117	0	(6)	0	7,117	15,000	22,117	[8]5,000	27,117
Oregon	50	284	0	0	334	100	434	0	434
Pennsylvania	63,940	0	0	18,812	82,752	[9]4,000	86,752	[10]3,600	90,352
South Dakota	0	0	2,185	0	2,185	1,000	3,185	0	3,185
Tennessee	2,530	0	0	0	2,530	2,000	4,530	0	4,530
Texas	6,048	0	10,293	0	16,341	[11]112,100	128,441	(11)	128,441
Utah	[12]23,186	173	0	0	23,359	[13]22,000	45,359	35,000	80,359
Virginia	9,216	0	0	335	9,551	5,000	14,551	100	14,651
Washington	1,867	4,180	117	5	6,169	30,000	36,169	15,000	51,169
West Virginia	100,150	0	0	0	100,150	0	100,150	0	100,150
Wyoming	12,703	123,240	(2)	0	135,943	700,000	835,943	100,000	935,943
Other States[14]	610	[15]32	[16]46	0	688	1,000	1,688	0	1,688
Total	747,357	485,766	478,134	19,662	1,730,919	1,849,649	3,580,568	387,696	3,968,264

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[1] Source of estimates: Alabama, W. C. Culbertson; Arkansas, B. R. Haley; Colorado, Holt (1975); Illinois, M. E. Hopkins and J. A. Simon; Indiana, C. E. Wier; Iowa, E. R. Landis; Kentucky, K. J. Englund; Missouri, Robertson (1971, 1973); Montana, R. E. Matson; New Mexico, Fassett and Hinds (1971); North Dakota, R. A. Brant; Ohio, H. R. Collins and D. O. Johnson from data in Struble and others (1971); Oklahoma, S. A. Friedman; Oregon, R. S. Mason; Pennsylvania anthracite, Arndt and others (1968); Pennsylvania bituminous coal, W. E. Edmunds; Tennessee, E. T. Luther: Texas lignite, Kaiser (1974); Virginia, K. J. Englund; Utah, H. H. Doelling; Washington, H. M. Beikman; Wyoming, N. M. Denson, G. B. Glass, W. R. Keefer, and E. M. Schell; remaining States, by the author.

[2] Small resources of lignite included under subbituminous coal.

[3] Small resources of anthracite in the Bering River field believed to be too badly crushed and faulted to be economically recoverable (Barnes, 1951).

[4] All tonnage is in the Black Mesa field. Some coal in the Dakota Formation is near the rank boundary between bituminous and subbituminous coal. Does not include small resources of thin and impure coal in the Deer Creek and Pinedale fields.

[5] Lignite.

[6] Small resources of lignite in western Kansas and western Oklahoma in beds generally less than 30 in. thick.

[7] After Fassett and Hinds (1971), who reported 85,222 million tons "inferred by zone" to an overburden depth of 3,000 ft in the Fruitland Formation of the San Juan basin. Their figure has been reduced by 19,666 million tons as reported by Read and others (1950) for coal in all categories also to an overburden depth of 3,000 ft in the Fruitland Formation of the San Juan basin. The figure of Read and others was based on measured surface sections and is included in the identified tonnage recorded in table 2.

[8] Includes 100 million tons inferred below 3,000 ft.

[9] Bituminous coal.

[10] Anthracite.

[11] Lignite, overburden 200–5,000 ft; identified and hypothetical resources undifferentiated. All beds assumed to be 2 ft thick, although many are thicker.

[12] Excludes coal in beds less than 4 ft thick.

[13] Includes coal in beds 14 in. or more thick, of which 15,000 million tons is in beds 4 ft or more thick.

[14] California, Idaho, Nebraska, and Nevada.

[15] California and Idaho.

[16] California, Idaho, Louisiana, and Mississippi.

Source: Averitt, Paul, U.S. Geological Survey Bulletin 1412, 1975, Table 3.

Economic and Technological Feasibility

Forecasts for energy requirements indicate that coal is expected to play an ever-increasing role in supplying the demand. Many projections indicate that coal production will approach a billion tons per year by 1985.

To reach the coal production forecast would require that both strip mining and deep mining be increased. Currently, the production of deep and strip coal is about equally divided. Strip mining is continuing to increase its total share of production.

To produce the 71 million tons that would be required to replace the Alaska Natural Gas Transportation System would require fifteen large new strip mines of about 1,000 acres per mine (15,000 acres annually, calculated at 9 acres per 10^{12} Btu), with a capacity of at least five million tons per year each. Large underground mines have a capacity of about two million tons per year. If the production were to come from underground mines, about 35 new large mines would need to be opened. To replace energy capacity which might be delivered by the two west coast pipelines only would require eight strip mines with capacities of five million tons per year each (about 8,000 acres annually) or 16 new underground mines. To replace the energy capacity which might be delivered by the Northern Border Pipeline only would require about eleven new strip mines with capacities of five million tons per year each (about 11,000 acres annually) or 28 new underground mines.

Each strip mine of 5 million tons annual capacity employs 610 persons and requires a capital expenditure of about $40,000,000 (National Petroleum Council, Coal Task Group, 1971). An underground mine with an annual production rate of 2 million tons would employ about 2,000 persons and capital expenditures would range upwards from $24,000,000 (National Petroleum Council, Coal Task Group, 1971).

There are many political and environmental constraints on the expansion of each type of mining. In addition, technological restraints are indicative of the maximum that can be expected in increased productive capability, and these are discussed for they bear on the rate of development that can be expected (Guccione, 1975a, 1975c).

Large draglines are required for production of coal by strip mining. A major constraint to expanding this type of production is the manufacturing rate of large draglines. Currently, large draglines have a delivery period of five years from the date of purchase. Six months to one and a half years are necessary for equipment erection at the site, but it is not all delayed until draglines are delivered.

Lead time for opening and initiating operation of new underground mines is about five years. Currently, underground mining equipment can be obtained in one to one and a half years. To improve underground productive capacity: techniques for degasification of coal mines in advance of mining are needed; speed of tunneling machines must be increased; methods of providing better underground health and safety goals must be developed; and trained manpower must be expanded.

Underground mining requires more skilled manpower than is needed for strip mining. Trained manpower is probably a major problem in expanding underground production. Mining engineers are in short supply, but many colleges have dropped courses in mining engineering. With well established training programs, underground miners could be trained in two to three years.

If production could be expanded to meet demand, adequate coal transportation would also be required. Currently, about two-thirds of all U.S. coal depends on rail movement, and one-fourth moves on waterways. If the production were to expand predominantly in the western states, existing rail facilities would have to be greatly expanded; water transport is not feasible. In addition, new speculative transportation techniques, such as coal slurry pipelines, may be required to get the quantities to the marketplace.

Expanding transportation capability will require new coal cars and locomotives, particularly of the unit train type. A typical unit train has a carrying capacity of about 10,000 tons, and a capital cost of about 2 million dollars. With a turn-around time of four days, each unit train could make 90 trips a year, or haul about 900,000 tons per year. The energy equivalent of the Alaska Natural Gas Transportation System would require 79 additional unit trains just for coal transportation. No calculation has been made of energy and material involved in building these trains nor the energy needed to operate them and its effect on the environment.

To transport the same equivalent amount of coal by pipeline would require one 38-inch or larger diameter pipeline, plus large volumes of scarce western water. The capital cost of a 1500 mile long 38-inch diameter coal pipeline would be at least 400 million dollars. About 15 pumping stations would be required along the estimated 1500 mile pipeline. A lead time of about two years exists in obtaining pumps. The coal would be dewatered at the receiving end. The separated water would be recycled by pipeline for reuse or clarified for discharge. Little experience is available on this mode of transport compared to train transport.

According to the 1974 Report on Fuel Costs (FPC), the average delivered price of coal at steam electric plants in North Dakota was $2.34 a ton, which is equivalent to 17.7 cents per million Btu's. In Montana, the price was $4.31 a ton, or equivalent to 27.7 cents per million Btu's. These prices would be representative of coal mined in the Northwest for shipment to the market areas to be served by the Arctic Gas pipeline system.

Environmental Impact

The environmental impact of coal utilization for energy production can be divided into three phases: environmental effects of coal extraction (underground and surface mining); coal transportation; coal conversion either by direct combustion or by conversion into synthetic fuels such as gas and liquids. The environmental effect of coal extraction, transportation, and combustion is presented in the sections following. The aspect of coal gasification processes is dealt with in the section, "Synthetic Natural Gas." More detailed information can be found in the Final Environmental Impact Statements on the Proposed Development of Coal Resources in the Eastern Powder River Coal Basin of Wyoming (U.S. Dept. Agriculture and others, 1974) and on the Proposed Coal Leasing Program (U.S. Dept. Interior, 1975).

Surface Mining--If coal is to serve as an alternative to the energy to be transported by the Alaska Natural Gas Transportation System, most likely it would be produced in the Rocky Mountain area, primarily by surface mining techniques (Atwood, 1975). Environmental residuals from surface mining for various regions of the nation are presented in Table 8-24. This shows the quantities of air and water pollutants, solid wastes, and land consumption associated with each type of surface mining operation. A summary of environmental residuals by regions is shown in Table 8-25. The

Table 8-24 Residuals for surface coal mining and reclamation

SYSTEM	Primary Efficiency	Water Pollutants Tons/10^{12} Btu's										Air Pollutants Tons/10^{12} Btu's						Solids (Tons/10^{12} Btu's)	Land $\left(\frac{\text{Acre-year}}{10^{12}\text{ Btu}}\right)$
		Acids	Bases	PO_4	NO_3	Total Dissolved Solids	Suspended Solids	Non-Deg. Org.	BOD	COD	Thermal (Btu's/10^{12})	Particulates	NO_x	SO_x	Hydrocarbons	CO	Aldehydes		
Northwest-Area Strip																			
Uncontrolled		NA	.226	NA	NA	.894	44.7	NA	NA	0	NA	2.05	1.16	.085	.116	.786	.019	730.	9.72
Controlled		NA	0.0	NA	NA	0.0	0.0	NA	NA	NA	NA	2.05	1.16	.085	.116	.786	.019	775.	4.14
Central-Area Strip																			
Uncontrolled		4.72	U	NA	NA	57.7	178	NA	NA	0	NA	.061	1.75	.128	.175	1.05	.029	535.	85.2
Controlled		0	.484	NA	NA	16.8	.242	NA	NA	0	NA	.061	1.75	.128	.175	1.05	.029	675.	19.4
Northern Appalachian-Area Strip																			
Uncontrolled		9.45	U	NA	NA	72.	8.44	NA	NA	0	NA	.055	1.57	.115	.157	1.06	.026	435.	89.8
Controlled		0	.546	NA	NA	18.9	.273	NA	NA	0	NA	.055	1.57	.115	.157	1.06	.026	777.	20.4
Contour																			
Uncontrolled		9.45	U	NA	NA	72.	524.	NA	NA	0	NA	.088	2.5	.18	.25	1.69	.040	7750. x10^6	220.
Controlled		0	.546	NA	NA	18.9	.273	NA	NA	0	NA	.088	2.5	.18	.25	1.69	.040	576.	28.5
Central Appalachian																			
Auger Uncontrolled		4.1	U	NA	NA	51.3	156.	NA	NA	0	NA	.09	2.5	.18	.25	1.69	.04	9.10 x10^4	112.
Controlled		0	.73	NA	NA	33.5	.25	NA	NA	0	NA	.09	2.5	.18	.25	1.69	.04	9.13 x10^4	25.3

*NA = not applicable, U = unknown.

For replacing West Coast pipelines at full capacity, values would be multiplied by 904.

For replacing Canadian Arctic Gas pipeline at full capacity, values would be multiplied by 1695.

Source: Hittman Associates, Inc., *Environmental Impacts, Efficiency, and Cost of Energy and End Use,* HIT-561, Phase I, Draft Final Report (Columbia, Maryland: Hittman Associates, Inc., September 1973); Tables 3-12 and footnotes.

Table 8-24 (cont.)

SYSTEM	Primary Efficiency	Water Pollutants Tons/10^{12} Btu's										Air Pollutants Tons/10^{12} Btu's						Solids (Tons/10^{12} Btu's)	Land $\left(\frac{\text{Acre-year}}{10^{12}\text{ Btu}}\right)$
		Acids	Bases	PO_4	NO_3	Total Dissolved Solids	Suspended Solids	Non-Deg. Org.	BOD	COD	Thermal (Btu's/10^{12})	Particulates	NO_x	SO_x	Hydrocarbons	CO	Aldehydes		
Contour																			
Uncontrolled		4.1	U	NA	NA	51.3	488.	NA	NA	0	NA	.09	2.4	.17	.242	1.47	.039	5.65 x10^5	222.
Controlled		0	.73	NA	NA	33.5	.25	NA	NA	0	NA	.09	2.4	.17	.242	1.47	.039	485.	28.9
Southwest-Area Strip																			
Uncontrolled		0	0	NA	NA	0	0	NA	NA	0	NA	8.0	.59	.043	.059	.4	.009	546.	37.5
Controlled		0	0	NA	NA	0	0	NA	NA	0	NA	8.0	.59	.043	.059	.4	.009	546.	13.4
Eastern Coal-Area Strip[a]																			
Controlled (B)		0	---	---	---	90.4	276.	---	---	---	0	70.3	0.1	0	0	0	0	120.5[c]	34.2
Eastern Coal-Area Strip																			
Uncontrolled (T)		286.1	---	---	---	273.2	514.6	---	---	---	0	-----	----	---	---	----	----	39.65[c]	----
Western Coal-Area Strip[a]																			
Controlled (B)		0	---	---	---	U	140.3	---	---	---	0	35	0.04	0	0	0	0	0	18.26

Source: University of Oklahoma, 1975, Table 1-17.

[a] Battelle, 1973

[b] Teknekron, 1973

[c] Includes overburden as solid waste.

Table 8-25 Summary of surface mining residuals $\underline{a}/$

	Northwest		Central		Northern Appalachia[c]		Central Appalachia[d]		Southwest	
	Unc.*	Con.**	Unc.	Con.	Unc.	Con.	Unc.	Con.	Unc.	Con.
Water (tons/10^{12} Btu)										
TDS	1	0	58	17	72	19	51	34	0	0
Acidity	0	0	5	0	10	0	4	0	0	0
SS	45	0	178	.2	8-523	.3	488	.3	0	0
Air (tons/10^{12} Btu)										
Particulates	2.05	2.05	.06	.06	.05-.09	.05-.09	.09	.09	8.0	8.0
Total of others[b]	2.17	2.17	3.13	3.13	2.9-4.7	2.9-4.7	4.5	4.5	1.1	1.1
Solids (tons/10^{12} Btu)	730	775	535	675	435-775,000	777-576	91,000 to 565,000[d]	91,300 - 485	546	546
Land										
Stripping (acres/10^{12} Btu)	0.83	0	6.8	0	7.2-17.6	0	8.9-17.7	0	2.89	0
Fixed[e] (total acres for mine life)	10	15	8.7	18.7	7.2-0	22-13.7	0	6.1	11	11

* Uncontrolled Case

**Controlled Case

[a] Area Strip and Contour Mining in Northern Appalachia, contour and augering in Central Appalachia; all others are Area Strip.

[b] Includes SO$_x$ NO$_x$, CO, hydrocarbons, aldehydes.

[c] First value is for area stripping, second value is for contour; when only one value is given it applies to both.

[d] First value is for augering, second value is for contour; when only one value is given it applies to both.

[e] For the uncontrolled case, this is total areas needed for refuse storage, for the controlled case, it is refuse storage, plus a water treatment facility.

Source: Hittman, 1973.

environmental residuals include conditions for both an uncontrolled and a controlled mining operation; controlled mining operations have undergone selected conditions of reclamation for environmental protection.

Values in Tables 8-24 and 8-25 are on the basis of tons of residuals per trillion Btu's. Thus, the environmental residuals of the surface mining alternative equivalent to the energy that would be carried by the proposed Alaska Natural Gas Transportation System (1695 x 10^{12} Btu per year) would be 1695 times the values in the tables. For the energy equivalents of the two combined west coast pipelines, a multiplier of 904 times the value in the tables should be used and 1309 for the Northern Border pipeline.

Water Quality--As shown in Tables 8-24 and 8-25, suspended solids are the principal water pollutant in surface mining. They are a function of the runoff from solid waste piles, and are produced at the rate of 2.54 tons per acre for each inch of runoff water. The largest runoff water rate occurs in Appalachia and is about 20 inches per year. Because of the high runoff rate in Appalachia and large areas of down-slope overburden, concentrations are particularly high in Appalachia contour mining. In the Southwest, where there is very little runoff because rainfall is limited, water pollutants are practically zero from surface mining. The case for controlled conditions in Table 8-25 assumes that drainage and runoff water are collected, allowed to settle and treated. Under these conditions suspended solids can be reduced to a 30-ppm concentration and a zero acid content. Control must be rigorously enforced if these minimums are to be realized.

Air Quality--Air pollutants originate from diesel fuel support equipment and wind erosion in surface mining operations. The emissions from these two sources are shown in Table 8-24. Emissions from diesel fuel equipment depend on the percent of equipment that is so powered.

Although electrically powered equipment is used in some mining operations, this means pollutants are generated at other locations. Air pollutants in the form of nitrogen oxides (approximately 62.8 tons per 10^{12} Btu's), sulfur oxides (approximately 21 tons per 10^{12} Btu's) and hydrocarbon emissions (approximately 13.9 tons per 10^{12} Btu's) could be emitted at electric generating plants to supply energy for strip mining.

Solid Wastes--As indicated in Table 8-24, solid waste from mining varies as a function of surface mining technique and variations are considerable.

In area strip mining, solid wastes are produced only during the initial box cut (5 acres) made to open the mine. The amount produced by this initial excavation is on the order of 500,000 tons of overburden. Under controlled conditions, an area mine's water treatment facility contributes additional sludge. The effect is to convert water pollutants into solid wastes.

For the contour mines in Northern and Central Appalachia, solid wastes and overburden are continually dumped downslope except for four feet of material above the height of the coal, which is used as backfilling for the bench. When the modified block cut mining technique is used as a control technology, the solids problem is greatly diminished.

As noted to replace the energy to be transported by the Alaska Natural Gas Transportation System would require 15 strip mines that would excavate 10,000 tons of coal per day each. These mines would produce 1000 tons of solid waste per day each as a minimum. The same production from contour mines could result in 120 times as much solid waste.

Uncontrolled disposal of waste, especially that containing carbon and sulfur, constitutes a source of pollution. Water flowing over waste disposal areas may transport leached minerals to adjacent areas. Dust-size particles commonly are transported by winds to contaminate adjacent land. Noxious gases from burning waste are hazardous to plants, animals, and people.

Waste disposal areas require a commitment of land resources and, if not properly constructed, present an unattractive appearance. Slides and slump failures, where waste is deposited on slopes, may not only adversely affect land and water resources, but also create a safety hazard.

Construction of slurry impoundments on underlying pervious bedrock may result in pollution of ground water. Percolation through the base of dikes permits slurry water to reach downstream drainage systems. Unless measures are taken by coal operators to seal this type of disposal area, unfavorable impacts may continue for decades. Use of appropriate treatment methods, coupled with effective enforcement of waste disposal regulations promulgated by State and Federal Governments, can minimize such effects on the environment.

Land Quality--Surface mining disturbs a considerable amount of surface acreage. Twc land impact categories included in Table 8-24 are the incremental land uses required by stripping the overburden, and the fixed land requirement for the life of the mine, including the land needed to store the initial boxcut refuse and, under controlled conditions, the water treatment facility and settling pond.

Land use for area stripping varies from 0.83 to 7.2 acres per 10^{12} Btu extracted and more commonly is closer to the maximum figure. Augering and contour mining have more severe land impacts than does area mining. Contour mining requires 17.7 acres per 10^{12} Btu. Four categories of land despoilment are involved in contour mining, (1) acreage stripped; (2) acreage covered by the spoil pile reaching downslope from the outcrop; (3) drainage ditches above the mining highwall; and (4) acreage affected by landslides. Of the approximately 18 acres affected, stripping and downslope spoils each account for 8 acres while the drainage ditch and landslides each consume one acre per 10^{12} Btu's mined. For augering, the impact is three acres for subsidence, three acres for the bench, and three acres of spoils from downslope deposits. Landslides are negligible in auger mining.

Under controlled conditions, it is assumed that a modified block cut is used for contour mining and that all land is reclaimed through backfilling, topsoil replacement, and revegetating. Disruption of the land surface by surface mining, unless proper precautionary measures are implemented, has adverse impacts on local environment including effects on wildlife, habitats, grazing, farming or other uses, leisure time activities in the area, and nearby residential and industrial activities.

Underground Mining--Environmental residuals for underground mining are given in Table 8-26 and summarized in Table 8-27. Multiplying the values in the tables by 1695 gives the residuals associated with replacement of the energy to be transported by the Alaska Natural Gas Transportation System.

The term "controlled conditions" as used on Tables 8-26 and 8-27 means the runoff and mine drainage waters are treated.

Table 8-26 Underground coal mining and reclamation residuals by region

SYSTEM	Primary Efficiency	Water Pollutants Tons/10^{12} Btu's										Air Pollutants Tons/10^{12} Btu's						Solids (Tons/10^{12} Btu's)	Land $\left(\frac{\text{Acre-year}}{10^{12}\text{ Btu}}\right)$
		Acids	Bases	PO_4	NO_3	Total Dissolved Solids	Suspended Solids	Non-Deg. Org.	BOD	COD	Thermal (Btu's/10^{12})	Particu-lates	NO_x	SO_x	Hydro-carbons	CO	Aldehydes		
Central Room and Pillar																			
Uncontrolled		3.54	U	NA	NA	616	.027	NA	NA	0	NA	0	0	0	0	0	0	3.28	146.0
Controlled		0	.732	NA	NA	25.1	.366	NA	NA	0	NA	0	0	0	0	0	0	99.3	148.0
Northern Appalachian Room and Pillar																			
Uncontrolled		119.	U	NA	NA	892.	.049	NA	NA	0	NA	0	0	0	0	0	0	2.66	177.
Controlled		0	2.06	NA	NA	71.4	1.03	NA	NA	0	NA	0	0	0	0	0	0	1800.	178.
Longwall																			
Uncontrolled		119.	U	NA	NA	892.	.049	NA	NA	0	NA	0	0	0	0	0	0	2.66	312.
Controlled		0	2.06	NA	NA	71.4	1.03	NA	NA	0	NA	0	0	0	0	0	0	1800.	313.
Central Appalachian Room and Pillar																			
Uncontrolled		16.4	U	NA	NA	567.	.048	NA	NA	0	NA	0	0	0	0	0	0	2.46	181.
Controlled		0	.85	NA	NA	29.2	.423	NA	NA	0	NA	0	0	0	0	0	0	442.	181.

To replace West Coast pipelines at full capacity values would be multiplied by 904.
To replace canadian Arctic gas pipeline at full capacity values would b multiplied by 1695.
To replace Norther Border pipeline at full capacity values would be multiplied by 1309.

Source: University of Oklahoma, 1975, Table 1-19.

Table 8-27 Summary of underground mining residuals

	Uncontrolled Case			Controlled Case		
	Central	Northern Appalachian	Central Appalachian	Central	Northern Appalachian	Central Appalachian
Water (tons/10^{12}Btu)						
TDS	616	892	567	25[c]	71.4[c]	29
Acidity	3.5[a]	119[b]	16.4	0	0	0
SS	0.05	0.03	.05	1.03	0.37	.4
Air	NONE					
Solids (tons/10^{12}Btu)	NONE			100	1800	440
Land						
Incremental (acres affected per 10^{12} Btu)	12[e]	14 to 34[d]	14.5[f]	-----	-----	----
Fixed (total acres for mine life)	----	----	----	7.8	64.6	15.5

Source: Hittman, 1973: Tables 3-12 and footnotes.

[a] 250 ppm.

[b] 3,000 ppm.

[c] Hardness at 2,000 ppm, Al=1 ppm, Mn=4 ppm, alkalinity=60 ppm.

[d] Higher value is for longwall mining. Assumed 5.1 foot seam thickness and 57 percent recovery efficiency.

[e] 6.8 foot seam thickness and 57 percent recovery efficiency.

[f] 4.7 foot seam thickness and 57 percent recovery efficiency.

Water Quality--Ground and surface waters entering active underground mine workings are normally pumped to the surface for disposal. Drainage of acid-mine water may be prevented by locating mine entries at elevations above the prevailing drainage level, by sealing abandoned mine entries, and by emplacing dams at critical points in abandoned underground entries and haulageways.

Unless they are controlled, mining and processing wastes contribute large volumes of sediment to nearby streams, are sources of acid drainage and are sources of air pollution where waste piles are burning. The most commonly used technique of preventing widespread scattering of mining and processing wastes is to compact the waste layers, followed by sealing with incombustible soil, after which vegetation is established to prevent infiltration of surface water and to minimize erosion.

Air Quality--Electrically powered equipment generally is used underground and air emissions are not a problem. Dust within the mine can be hazardous to the health of the miners.

Dust from mine access roads, coal handling, and processing can be alleviated by hard surfacing roads, or through abated techniques by oiling or chemical treatment of the road surface. Dust from coal handling and processing can be abated by spray treatment at transfer points and by enclosing coal handling and processing structures. Dust problems in live coal storage piles can be reduced by water sprays or oiling; dead storage piles can be sealed with asphaltic or chemical materials.

Solid Wastes--In underground mines, the amount of solids produced when the initial shaft is sunk is about 3000 tons. However, for mines equivalent to the energy to be transported by the Alaska Natural Gas Transportation System, solids extracted when water is treated would be 3 million tons per year for typical mines in Northern Appalachia, 728,000 tons per year in Central Appalachia, or 156,000 tons per year in the Central area.

Land Quality--Land impacts include subsidence and refuse storage sites as well as a site for a water treatment facility under controlled conditions.

Subsidence of the ground surface is common above many abandoned and some active coal mines. The amount of subsidence relates to the mining method employed, amount of coal removed, thickness of the coal bed, and composition and strength of rocks overlying the coal. Subsidence of large areas commonly destroys man-made structures and disrupts the ground water hydrology, cuts off surface and subsurface water recharge, adversely affects the quality of underground and surface waters, redirects the planned drainage of a mine, disrupts surface drainage, and in periods of heavy rainfall localizes flooding. In some localities subsidence causes landslides.

Health and Safety--Health and safety of mine employees must be considered along with other environmental costs of mining. In 1970, there were 31 fatal and 1,010 nonfatal accidents connected with open-pit mining. Underground mining was responsible for 219 fatal and 8,710 nonfatal accidents in 1970. Black lung disease has been a serious problem in the past. Recent regulations and technological advances concerning the control of the quantity of dust in mining operations, however, hopefully will reduce or eliminate this coal mining associated health hazard.

Transportation--The impact of coal production is still felt in transport to the market areas. A way to eliminate this impact is to situate new power plants at or near mine locations. The transport of electricity to the market areas by transmission lines causes fewer environmental problems than the transport of a vast quantity of coal, but may result in more net energy loss in conversion than in transportation.

If coal is transported to market, four systems would be available for transportation from Rocky Mountain States to west coast or eastern market areas: trucks, railroads, conveyors, and coal slurry pipelines. Water transportation may be discounted because of the lack of navigable waterways.

Truck Transportation--Truck transportation is commonly used for relatively short hauls, as in supplying mine-mouth utilization plants. The roads are usually less than 5 miles long and have little effect on the general public.

Railway--The impact of rail transportation varies to some degree with the types of locomotive power used. Diesel locomotives are sources of exhaust gas and noise pollution; electric locomotives are not sources of air pollution per se, but the pollution source is the power station.

Rail transport using diesel locomotives is a source of air and noise pollutants from engine exhaust systems. Effective maintenance of engine combustion systems and efficient mufflers can reduce air and noise pollution levels from this system. Coal dust lost in transit can be reduced by using partially covered hoppers or by oiling the coal during loading. Dusting during loading and unloading can be reduced with a combination of dust suppression sprays and enclosed chutes or bins.

The right-of-way for a railroad constitutes a permanent commitment of the land surface, making it unavailable for other uses. Free travel of vehicles, people and animals across the committed area is restricted. The potential for collisions with trains exists, as does the hazard of railway accidents.

Conveyors--Overland conveyor systems are usually used to transport coal for short distances near the mine.

Conveyor system installations constitute a permanent commitment of the land surface and restrict free movement of vehicles, people, and animals. Uncovered or partly covered conveyors yield dust in transit because of exposure to winds; falling material may constitute a safety hazard to persons or animals. Fencing or complete enclosure can reduce or eliminate these hazards. Conveyor support structures as well as the conveyors, are obvious visual intrusions.

Coal Slurry Pipelines--The principal impacts of coal slurry pipeline systems are: permanent commitment of land; need for an adequate water supply; and disposal of large volumes of polluted water.

Land surface requirements are minimal because the pipeline is buried and appears at the surface only at drainage crossings and pumping stations, though a right-of-way must be maintained for the pipeline. Slurry preparation plants, pumping stations, and terminal coal dewatering and storage facilities are permanent above-ground structures. The pipeline, after burial, does not interfere with the free movement of vehicles, people or animals. Noise sources are at the slurry preparation plant and at pumping stations. Dust problems associated with pipelines are confined to the slurry preparation plant where the coal is crushed, screened, and stored; commonly employed suppression methods could minimize this problem.

Large quantities of water are required to transport coal, about 11 million gallons per 10^{12} Btu of coal input. Disposal of this water at the terminus of a pipeline could have an major impact on water quality if such water is not properly contained or when it is not economically feasible to recycle this water for transportation purposes.

Coal Combustion--Approximately two-thirds of current coal production (614×10^6 tons in 1973) is used to generate electricity by direct combustion. Twenty-five percent is used for making coke at home and abroad, with the balance going into the industrial and retail market (FEA, Project Independence Coal data, 1974). The principal pollutants from coal combustion are: sulfur oxides; nitrogen oxides; airborne particulates; potentially hazardous materials; and waste heat. In addition, the emission control technologies now being developed create in themselves secondary environmental problems which include flue gas desulfurization sludge (FGD); spent sorbent materials from fluidized-bed combustion (FBC); fly-ash collected by particulates emission control devices; and water pollution associated from runoff and leaching of FGD and FBC.

Environmental and health impacts of coal combustion are of primary importance in the further development of coal as an energy source.

References

Further information on coal may be found in the following references, which are cited in full in the list in Section 8-F-12, References, of this volume: Averitt, 1975; DeCarlo and others, 1966; FEA, Interagency Task Force on Coal, 1974; FPC, 1975c; Guccione, 1975a, 1975c; Hittman Associates, 1974-75; Interagency Coal Task Force, 1974; McNay, 1970; NPC, Coal Task Group, 1971; U.S. Bur. Mines, 1974; U.S. Bur. Mines, Div. Fossil Fuels, 1974; U.S. Dept. Agriculture and others, 1974; U.S. Dept. Interior, 1975; U.S. Geol. Survey, 1960, 1967, 1972; and Univ. Oklahoma, 1975, chap. 1.

8-E-2. Petroleum

Resource Base

A large part of the world's petroleum production moves from the energy surplus regions of the Middle East, Africa, and Latin America to energy deficient regions. More than half of the oil entering trade is supplied by Arab nations, most of whom belong to the Organization of Petroleum Exporting Countries. In 1974, the Arab country members of OPEC were Algeria, Bahrain, Egypt, Iraq, Kuwait, Libya, Qatar, Saudi Arabia, Syria, United Arab Emirates. Non-Arab OPEC countries were Ecuador, Indonesia, Iran, Nigeria, and Venezuela. The Arab countries are designated as OAPEC countries. Prior to the Arab Oil Embargo in 1974, the United States imported about 31 percent of its crude oil imports from Arab countries, members of OAPEC. Also, additional amounts of refined products from Middle East crude refined in Western Europe were imported by the United States.

In 1973, United States imports of crude oil and refined products amounted to 2,263 million barrels daily, representing 26 percent of the Nation's total petroleum requirements for the year and 17 percent of its total energy consumption. Of these imports, 1.6 million barrels daily came from Arab countries and 4.6 million barrels daily from non-Arab countries. Despite the interruption of oil imports from the Middle East during the first quarter of 1974, and the precipitous increases in prices after imports were resumed, crude and refined products imports in 1974 were 2,269 million barrels, slightly above the 1973 level. In September 1974, an estimated 25 percent of U.S. crude oil imports were from OAPEC countries.

Sufficient oil is available for import to replace the equivalent energy of Alaska natural gas. Increasing price of such oil poses serious economic strains. Far more serious is the question of the future delivery of oil in large volume over and above that currently imported. This is a major political question and is not considered here. It is unrealistic to assume that sufficient oil will be imported to replace the energy equivalent of Alaska Natural Gas Transportation System.

At current usage relative to the domestic resource base, petroleum and natural gas will be depleted much sooner than coal. Energy from the Nation's petroleum reserves does not appear to be a realistic long-run substitute for deficiencies in natural gas. In terms of the usage of fossil fuels, petroleum is utilized to produce 46 percent of our total energy, natural gas 32 percent, and coal 17 percent. Because of the current heavy dependence on this fuel and the high interest in it, the resource base and a few other considerations will be highlighted.

The U.S. Geological Survey (Miller and others, 1975) estimates that for the United States, measured reserves of crude oil and natural gas liquids are 40.6 billion barrels; indicated and inferred reserves are 33.7 million barrels; and undiscovered economically recoverable resources range from 61 to 149 billion barrels (Table 8-28). The National Academy of Sciences' Committee on Mineral Resources and the Environment (1975) estimates that undiscovered economically recoverable resources are 113 billion barrels for the United States. Oil-in-place resources for various regions as estimated by the National Petroleum Council are given in Table 8-29. Domestic and world petroleum recoverable resources and proved reserves are compared in Table 8-30.

Although variations exist in estimating the petroleum and natural gas resource base due to different predictive techniques, the relative quantities are quite small compared to coal. For example, the U.S. resources of petroleum contain about 1,000 quadrillion BTU's, whereas coal contains 33,000 quadrillion Btu's. Natural gas contains 800 quadrillion Btu's in the resource base. Oil shales and tar sands contain 1500 quadrillion Btu's.

In recent years, the domestic production of oil and gas has been increasing steadily in offshore locations. In 1972 offshore production rose to 12 percent of the total of national production. Most recently the national goal has been to accelerate leasing of acreage on the Outer Continental Shelf as rapidly as possible. A number of specific regions of the Outer Continental Shelf have been identified by the Bureau of Land Management (BLM) tentative lease schedule for development by 1985. These include the Gulf of Mexico, Pacific Coast, Atlantic Coast, and Alaska. The proposed leasing plan is described in the "Final Environmental Statement on the Proposed Increase in Oil and Gas Leasing on the Outer Continental Shelf," prepared by the Bureau of Land Management (U.S. Dept. Interior, BLM, 1975a) and released to the public on July 5, 1975.

Most present production is taking place in the Gulf of Mexico. The two offshore regions which might be considered as alternatives to parts of the Alaska Natural Gas Transportation System are the Pacific and Atlantic

Table 8-28 Production, reserves, and undiscovered recoverable resources of crude oil and natural gas liquids for the United States, December 31, 1974 (onshore and offshore to water depth of 200 meters)

Area	Cumulative Production	Reserves			Undiscovered Recoverable Resources
		Demonstrated			
		Measured[2]	Indicated[3]	Inferred[4]	Range[5,6] (95%-5%)
		Crude Oil[1] (billions of barrels)			
Lower 48 Onshore-----------	99.892	21.086	4.315	14.3	29 - 64
Alaska Onshore-------------	0.154	9.944	0.013	6.1	6 - 19
Total Onshore------------	100.046	31.030	4.328	20.4	37 - 81
Lower 48 Offshore----------	5.634	3.070	0.308	2.6	5 - 18
Alaska Offshore------------	0.456	0.150	Negligible	0.1	3 - 31
Total Offshore-----------	6.090	3.220	0.308	2.7	10 - 49
Total Onshore and Offshore-------------	106.136	34.250	4.636	23.1	50 - 127
		Natural Gas Liquids (billions of barrels)			
Total Onshore and Offshore-	15.730	6.350	Not Applicable	6	[7] 11 - 22

[1] Cumulative production and estimates of reserves and resources reflect an assumed recovery of about 32 percent of the oil and 80 percent of the gas-in-place. Some portion of the remaining oil-in-place is recoverable through application of improved recovery techniques. Estimates are based on figures released by the American Petroleum Institute (API) and the American Gas Association (AGA) in April 1975.

[2] Identified resources that can be economically extracted with existing technology. Estimates are the "proved reserves" of the API and AGA.

[3] Identified resources, economically recoverable if known fluid injection technology is applied. Estimates are from the API.

[4] Resources estimated to be recoverable in the future as a result of extensions, revisions of estimates, and new pays in known fields beyond those shown in indicated reserves.

[5] The low value of the range is the quantity associated with a 95 percent probability (19 in 20 chance) that there is at least this amount. The high value is the quantity with a 5 percent probability (1 in 20 chance) that there is at least this amount. Totals for the low and high values are not obtained by arithmetic summation; they are derived by statistical methods.

[6] The reader is cautioned against averaging ranges. Statistical mean values are shown in tables 4 and 5.

[7] The calculated estimates of undiscovered recoverable resources are derived from natural gas estimates by applying historical NGL/Natural Gas ratios. These figures suggest that if added to crude oil estimates, natural gas liquids would increase the estimates of petroleum liquids by approximately 20 percent.

Source: Miller, B. M., and others, U.S. Geological Survey circular 725, 1975 Table 1

Table 8-29 Production, reserves and undiscovered recoverable oil resources for the United States, December 31, 1974 (in billion barrels)

Regions	Cumulative Production	Demonstrated Reserves		Total Cumulative Production + Demonstrated Reserves	Inferred Reserves[1]	Undiscovered Recoverable Resources	
		Measured	Indicated			Statistical Mean	Estimated Range[2] (95%-5%)
ONSHORE							
1. Alaska--------------------	0.154	9.944	0.013	10.111	[3] 6.1	12	6 - 19
2. Pacific Coastal States-----	15.254	2.699	1.091	19.044	0.3	7	4 - 11
3. Western Rocky Mountains----	1.115	0.417	0.089	1.621	0.7	4	2 - 8
4. Northern Rocky Mountains---	6.021	1.461	0.256	7.738	1.2	7	5 - 11
5. West Texas and Eastern New Mexico---------------	21.385	7.060	1.991	30.436	1.6	8	4 - 14
6. Western Gulf Basin---------	31.345	7.082	0.587	39.014	[4] 8.6	8	5 - 12
7. Mid-Continent-------------	17.203	1.805	0.211	19.219	1.3	6	3 - 12
8. Michigan Basin------------	0.645	0.082	0.008	0.735	0.2	1	0.3 - 2
9. Eastern Interior-----------	4.346	0.283	0.009	4.638	0.3	1	0.6 - 2
10. Appalachians--------------	2.539	0.155	0.067	2.761	[5] Negl.	1	0.4 - 2
11. Eastern Gulf and Atlantic Coastal Plain------------	0.039	0.042	0.006	0.087	0.1	1	0.2 - 2
Total Lower 48 Onshore----	99.892	21.086	4.315	125.293	14.3	44	29 - 64
Total Onshore United States----------	100.046	31.030	4.328	135.404	20.4	56	37 - 81
OFFSHORE (0-200 metres)							
1A. Alaska--------------------	0.456	0.150	[5] Negl.	0.606	[3] 0.1	15	3 - 31
2A. Pacific Coastal States----	1.499	0.858	0.258	2.615	0.2	3	2 - 5
6A. Gulf of Mexico------------	4.135	2.212	0.050	6.397	2.4	5	3 - 8
11A. Atlantic Coastal States---	0.000	0.000	0.000	0.000	0.0	3	[6] 2 - 4
Total Lower 48 Offshore--	5.634	3.070	0.308	9.012	2.6	11	5 - 18
Total Offshore United States---------	6.090	3.220	0.308	9.618	2.7	26	10 - 49
Total Lower 48-------	105.526	24.156	4.623	134.305	16.9	55	36 - 81
Total Alaska---------	0.610	10.094	0.013	10.717	6.2	27	12 - 49
TOTAL UNITED STATES-	106.136	34.250	4.636	145.022	23.1	82	50 - 127

[1] Inferred reserves were derived for all regions based on historical data. (See Appendix).

[2] The low value of the range is the quantity associated with a 95 percent probability (19 in 20 chance) that there is at least this amount. The high value is the quantity with a 5 percent probability (1 in 20 chance) that there is at least this amount. Totals for the low and high values are not obtained by arithmetic summation; they are derived by statistical methods.

[3] Inferred reserves based on national onshore average.

[4] Inferred reserves based on data in AAPG Memoir 15 (1971).

[5] Negligible--less than 0.001 billion barrels.

[6] Estimates reported at the 75 and 25 percent probability levels because, in this area, these levels are judged to be more applicable for some planning purposes. It can also be noted that in frontier areas, lacking discovered indigenous or adjacent recoverable hydrocarbons, uncertainty is sufficiently great as to weaken probability estimates at extreme ranges. For purposes of comparison with other recorded ranges, the 95-5 percent probability range in offshore Atlantic is 0-6 billion barrels of oil.

Source: Miller, B. M., and others, U.S. Geological Survey Circular 725, 1975, Table 4.

Table 8-30 Estimated world supply function for petroleum (including crude petroleum and natural gas liquids)

	Billion barrels	Quadrillion Btu
Remaining recoverable resources:[1]		
United States	273- 494	1,469- 2,657
Rest of world	2,035	10,956
World	2,308-2,529	12,425-13,613
Proved recoverable reserves:[2]		
United States	36	194
Rest of world	589	3,169
World	625	3,363

[1] Estimated remaining recoverable resources, discovered and undiscovered, that could be made available under certain economic and technological conditions.

[2] Proved reserves are those recoverable under existing economic and operating conditions as reported by the American Petroleum Institute, Dec. 31, 1973.

Sources: *Reserves of . . . Crude Oil and Natural Gas Liquids in the United States,* American Petroleum Institute, Vol. 26, 1972; *Energy Resources of the United States,* U.S. Geological Survey, Circular 650, U.S. Geological Survey, Washington, D.C., 1972; *Summary Petroleum and Selected Mineral Statistics for 120 Countries . . .* Geological Survey Professional Paper 817, 1973; *Commodity Data Summaries,* Bureau of Mines, U.S. Department of the Interior Press Release, Geological Survey, March 26, 1974. ; FPC, 1975b National Gas Survey, Vol. I, Chap. 6, Table 6-7.

Prepared by: Office of Economics, Federal Power Commission.

Regions. Production in the Pacific Region is from the Santa Barbara Channel area and through 1972, approximately 1.3 billion barrels of oil and over 3 trillion cubic feet of gas were recovered (U.S.G.S., 1974). Resources of the Pacific Region are estimated at about nine billion barrels, in the Santa Barbara Channel and outside the channel islands (Kash and others, 1973).

No exploratory drilling has been done on the Atlantic OCS, although discoveries have been made offshore of Nova Scotia in Canadian waters. A number of areas with considerable potential have been identified and resource estimates of 48 billion barrels have been made by the U.S. Geological Survey (Kash and others, 1973).

The total production of oil and natural gas liquids from domestic onshore sources in the conterminous United States in 1974 averaged slightly less than 11 million barrels per day from reserves of 34.2 billion barrels; reserves are being found at a rate of about 3.4 billion barrels per year (NPC, 1974). The results of recent U.S. Geological Survey studies of onshore and offshore resources of oil and gas in the United States and Alaska are shown in Figures 8-4, 8-5, and 8-6 (under the Natural Gas section) and Figures 8-11 and 8-12. Although higher crude oil prices have stimulated exploration and drilling for new supplies, it is too soon for these efforts to overcome the decline which resulted from years of depressed exploration activity.

Incremental Production

The estimated gas supplies that could be made available by the Alaska Natural Gas Transportation System are 2.25 Bcfd for the Alaskan gas only and 4.5 Bcfd for Alaskan and Canadian gas combined. These amounts would have to be replaced by the Btu equivalence in increased production of petroleum if petroleum is to serve as an alternative energy source. Crude oils vary in heat content. Estimates of amounts of petroleum needed to replace Arctic gas, based on a heat content of 5.8 x 10^6 Btu/bbl. are tabulated below.

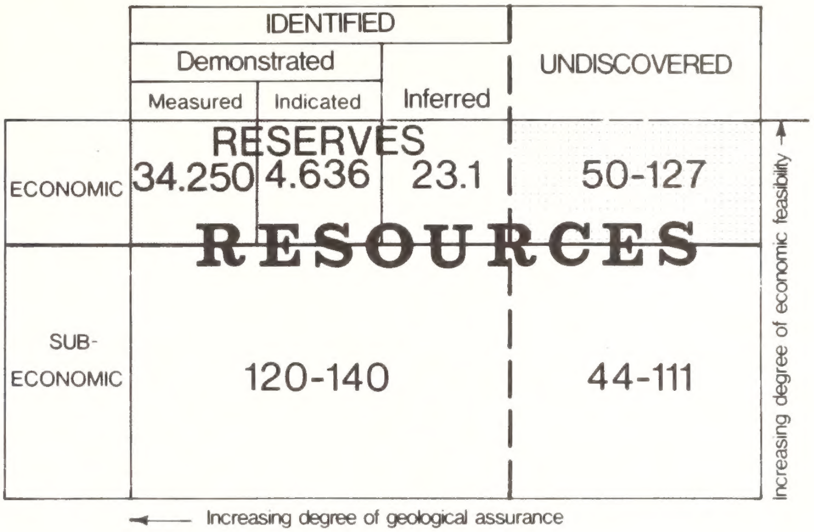
Year	Alaska and Canadian Arctic	Los Angeles and San Francisco (maximum capacity)	Northern Border (maximum capacity)
	(million of barrels of oil per year)		
1975	-	-	-
1980	228	78	78
1985	292	228	156
1990	292	228	156

Economic and Technological Feasibility

Petroleum and natural gas can be used interchangeably as fuel on an equivalent Btu basis for most modern thermal steam electric power plants. This substitution is also feasible for most large industrial and commercial heating systems, but is far more complex for residential heating systems.

For over forty years, natural gas has been the most economic fuel choice, being priced at from 25 percent to 50 percent of the average oil price on a Btu basis. This differential has been maintained because of a number of factors including FPC and State PUC regulations, distribution system costs, and source-market geophysical logistics. For a number of years, natural gas was a useless by-product in the production of petroleum

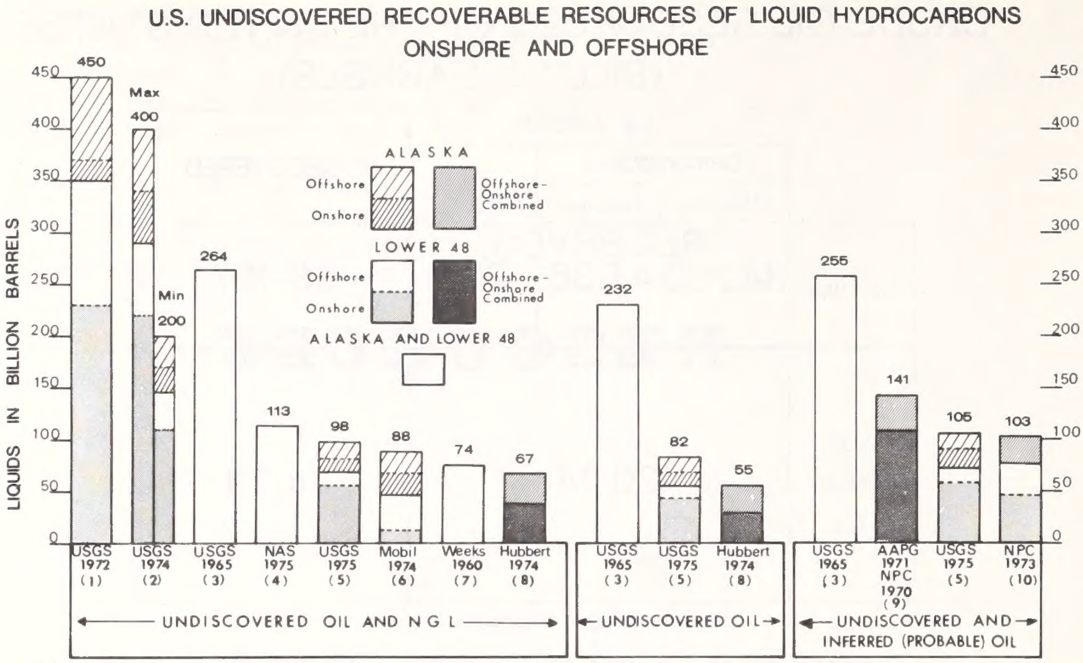
CRUDE OIL RESOURCES OF THE UNITED STATES
(BILLION BARRELS)



Total U.S. Cumulative Oil Production 106 Billion Barrels
12/31/74

Source: Miller, B. M., and others, U.S. Geological Survey Circular 725, 1975, Figure 13

Figure 8-11 Diagrammatic representation of estimated crude oil resources using U.S. Geological Survey's resource classification system (modified from McKelvey, 1973). Cumulative oil production is cited below the figure.



(1) Theobald and others, U.S. Geol. Survey Circ 650, 1972. Includes water depth to 2,500 m (8,200 ft).
(2) U.S. Geol. Survey News Release, March 26, 1974. Includes water depth to 200 m (660 ft).
(3) Hendricks, U.S. Geol. Survey Circ. 522, 1965. Adjusted through 1974. Includes water depth to 200 m (660 ft).
(4) Nat'l. Academy of Sciences, "Mineral Resources and the Environment," 1975. (See National Research Council). Water depth not indicated.
(5) U.S. Geol. Survey Mean , Oil and Gas Branch Resource Appraisal Group, 1975. Includes water depth to 200 m (660 ft).
(6) Mobil Oil Corp., Expected Value: Science, 12 July 1974. (See Gillette). Includes water depth to 1830 m (6000 ft).
(7) Weeks, L.G., Geotimes, July-Aug., 1960. Adjusted through 1974. Water depth not indicated.
(8) Hubbert, Senate Committee Report, 1974. Includes water depth to 200 m (660 ft).
(9) Am. Assoc. Petroleum Geologists Mem. 15, 1971. Also National Petroleum Council, "Future petroleum provinces of the United States," 1970. Some areas are excluded from this estimate. Includes water depth to 2,500 m (8,200 ft).
(10) National Petroleum Council, "U.S. Energy outlook -- oil and gas availability," 1973. Includes water depth to 2,500 m (8,200 ft).

Source: Miller, B. M., and others, U.S. Geological Survey Circular 725, 1975, Figure 37

Figure 8-12 Comparative estimates of oil resources in the United States

and was simply flared due to low return on the capital cost of a gathering system.

The net result of the favorable economic status of natural gas, compared with alternative fuels, has been the development of a large national demand for this fuel form serviced by a capital intensive gathering, transportation, and distribution industry.

While there is no technological barrier for substitution of gas by petroleum fuels, there is an economic one. As noted, without additional oil discoveries, domestic oil reserves would be depleted in less than ten years. Even with additional discoveries, assuming no increase in demand, the time period for oil depletion could be extended to perhaps 30 years. However, the national oil consumption in 1974 was over 17 billion barrels/day and the deficit between the demand and domestic production had to be made up by oil imports. Demand for petroleum to be used for transportation continues to rise. Oil provides also the feedstock for the rapidly growing petrochemical industry, further increasing the import of oil.

Environmental Impact

Because increased domestic production of petroleum does not appear to be a realistic substitute for the deficiencies in energy supply which might be made up by natural gas from Alaska, no environmental impacts are presented here. It is clear that the impact of increased production will be mostly in offshore areas and that it will differ in degree and kind from the impact of onshore drilling.

The import of petroleum in ever increasing quantities brings with it some of the problems associated with offshore drilling and adds to them the hazards of increased shipping by oil tanker. Such hazards need not be discussed here.

References

Further information on petroleum may be found in the following references, which are cited in full in the list in Section 8-F-12, References, of this volume: Am. Assoc. Petroleum Geologists, 1971; Cram, 1971; Dupree and Corsentino, 1975; FPC, 1975b; Gillette, 1974; Hendricks, 1965; Hittman Associates, 1974-75; Hubbert, 1974; Kash and others, 1973; McKelvey, 1974,1975; Miller and others, 1975; National Academy of Sciences, 1975; NPC, 1974; NPC, Comm. Energy Outlook, 1973a; Theobald and others, 1972; U.S. Coast Guard, 1970, 1972, 1974; U.S. Congress, Senate, Comm. Interior and Insular Affairs, 1974; U.S. Dept. Commerce, 1972; U.S. Dept. Interior, 1973c; U.S. Dept. Interior, BLM, 1975a,b,c; U.S. Geol. Survey, 1974, 1975a, 1975b; Univ. Oklahoma, 1975, chap. 3; and Weeks, 1960.

8-E-3. Oil Shale

Oil from shale constitutes a potentially significant addition to the nation's energy supply, but one that is technologically difficult to institute. The process requires mining the source rock either by underground or strip methods, heating it to distill oil and gas, and then transporting the products of distillation to market. About 228 million barrels per year would be needed in 1980 to replace the energy which might become available from the Alaska Natural Gas Transportation System, and about 292 million barrels would be needed in 1985.

At this stage of technology it is unrealistic to assume that significant amounts of energy would be available from oil shale during the time frame of gas production from the proposed Alaska Natural Gas Transportation System. The environmental pollutants are slightly different from those which might result from mining the same energy equivalents of coal but are of approximately the same volume expectable from a massive program of mining. Most oil shale is in Utah and Colorado. Should production of oil shale reach that of the energy equivalents which could be obtained from the proposed pipeline system, mining and processing probably would require between 5 and 10 percent of the water in the Colorado River.

References

Further information on oil shale may be found in the following references, which are cited in full in the list in Section 8-F-12, References, of this volume: Campbell, 1973; Culbertson and Pitman, 1973; Duncan and Swanson, 1965; Guccione, 1975b; Hittman Associates, 1974-75, vol. 2, 1975; NPC, Comm. on U.S. Energy Outlook, 1972; U.S. Dept. Interior, 1973b; U.S. Dept. Interior, BLM, 1973; and Univ. Oklahoma, 1975, chap. 2.

8-E-4. Synthetic Natural Gas

Resource Base

The resource bases for coal and petroleum which might be used as feedstocks for production of synthetic natural gas have been discussed above. It was concluded that supplies of oil to replace natural gas appear remote. Because of short supply, the use of light hydrocarbon to produce feedstocks for synthetic natural gas does not appear feasible. Concern is with hydrogenation of coal to produce various hydrocarbon liquid and gaseous substitutes for natural oil and gas.

Water is an important element in the coal gasification process. About 70 percent of remaining coal resources are in the West. Water supplies are limited. SNG (synthetic natural gas) plants would probably require construction of reservoirs and adequate systems to store and carry water, and, if there is not enough water, would conflict with other water uses.

Economic and Technological Feasibility

It is unrealistic to assume that SNG can be substituted for the energy available in Alaska Natural Gas Transportation System within the time frame of the proposed project, but because of the interest in the issue, some discussion will be given here. Because of the present lack of a commercial synthetic gas industry and the uncertainty of the related economics and technology, production projections of synthetic natural gas are uncertain.

The main barriers to synthetic gas development to date have been economics and technology. Most processes have not yet advanced beyond the pilot plant stage, have not been tested commercially, and have not been able to compete in cost with other energy sources. Considerable research and development has been done and more is being conducted by the Federal Government and private industry. While many individual units for commercial gas processes have been tested, synthetic gas has not yet been proved economical in the United States. Several commercial plants in Western Europe use the Lurgi coal gasification process to produce low Btu value gas. The Department of the Interior's 1972 coal research report (USDI, Office of Coal Research, 1972) described much of the work currently in progress.

The feasibility of producing synthetic natural gas from coal as an alternative to the proposed Alaska Natural Gas Transportation System depends upon the rates at which technological systems are developed, tested, and proved economic, and at which commercial-scale plants are built. Plans for ten synthetic gas-coal projects have been announced (Table 8-31).

The first coal gasification complexes are scheduled for operation in the latter part of this decade, and are to be located in the northwestern part of New Mexico. Over the long term, however, the Montana, Wyoming, North Dakota area is expected to be the major supply center for coal gasification. Projects in this region are expected to begin about 1980. Although some coal reserves east of the Mississippi will be designated for coal gasification, most of the suitable sites are in the West.

Factors that will influence the development of coal gasification include availability of coal, environmental constraints on coal production and SNG production, capital availability, health and safety considerations in coal mining, and availability of water.

As noted, SNG can be made from petroleum. Such gas has been produced commercially in Europe and plants are in the planning stage for the U.S. Feedstocks used range from naphtha and other lighter hydrocarbons to crude oil. Processes being considered include: thermal cracking in steam, thermal cracking in a hydrogen-rich atmosphere, catalytic cracking in steam, and partial oxidation.

Incremental Production

A typical coal gasification plant will produce 250 million cubic feet per day of pipeline quality gas, consume 6 to 10 million tons of coal yearly, use about 6,000 gallons of water per minute, and have capital costs of over $400 million, including the development of the coal mine according to a talk by Dr. Thomas A. Henrie, Bureau of Mines, Deputy Director, Mineral Resources and Environmental Development, given at a coal seminar, August 21, 1973 at Price, Utah.

Synthetic gas made from coal has a slightly lower heat content than natural gas. One cubic foot of synthetic natural gas is estimated to have a heat content of 900-925 Btu (U.S. Dept. Interior, BLM, 1973).

To replace the amount of gas to be transported by the proposed Alaska Natural Gas Transportation System (4.5 Bcfd at full capacity) would require 18 major coal gasification plants. These would be needed in addition to the plants for which plans have been announced. An additional 108 to 180 million tons per year of coal would be needed to support 18 plants.

If synthetic natural gas were to be a substitute for the Alaska Natural Gas Transportation System, a pipeline would be required to move the synthetic gas from the northwest into the midwestern and eastern markets. However, the Alaskan and Canadian pipeline portions of the proposed Alaska Natural Gas Transportation System would not be required.

Environmental Impact

Like natural gas, synthetic natural gas from oil and coal is a clean-burning fuel because sulfur content has been reduced and no particulate matter is emitted at the point of combustion. However, coal gasification and liquefaction processes can produce pollution if controls are not an integral part of the manufacturing operations. Because of the Nation's

Table 8-31 Announced plans for synthetic gas-coal projects

Location of Site	Type of Process	Companies Participating	Type of Gas Produced	Type of Coal	Coal Reserves (MMT)	Coal Consumption Per Plant[1] (Tons/day)	Estimated Investment Per Plant[1] (MM$)	Potential Number of Plants	Comments
Four Corners, New Mexico . .	Lurgi	El Paso Natural Gas Company	SNG (972 Btu)	Subbituminous	709	26,600	333.2 (and 65.3 for mine)	3	Planned Startup–June 1976
	Lurgi	Transwestern Pipeline Company, Pacific Lighting Company, Utah International	SNG (972 Btu)	Subbituminous	824	26,300	405.9 (includes 67 miles of pipeline)	4	Planned Startup–1976
	–	Eastern Gas and Fuel Associates, Texas Gas Transmission	–	Subbituminous	–	–	–	–	Granted Rights to Explore 40,000 Acres of Federal and State Land
North Dakota	–	Coteau Properties, Michigan-Wisconsin Pipe Line Company	–	Lignite	2,700	–	–	12	Lease Extended to 1993
Dunn County, North Dakota.	–	Natural Gas Pipeline Company of America	–	Lignite	2,000	–	–	8	Coal Reserved for Future Gasification–Reserves Equal to 17 Tcf of SNG
Powder River Basin, Montana	Lurgi	Northern Natural Gas Company, Cities Service Gas Company	SNG	–	500	–	$350	2	Planned Startup–1st Plant–1979 Plans to build 700 mile pipeline to market–Negotiating for additional 500 Million Tons of Coal
Illinois	Lurgi	Panhandle Eastern Pipe Line Company Peabody Coal Company	SNG (972 Btu)	Noncaking	–	–	–	–	Feasibility Study
Illinois Basin	–	Texas Gas Transmission, Consolidated Coal Company	SNG	Bituminous	–	–	–	–	To be held for 10 years for possible coal gasification
West Virginia[2]	–	Columbia Gas System	SNG	Bituminous	293	–	–	2	Coring for possible plant sites
–	–	Colorado Interstate Gas Corp. Westmoreland Resources	–	–	–	–	–	–	10 Year option on coal reserves–coal gasification feasibility study underway

–Not announced.

[1] Commercial sized plants producing 250 MMcf/d of pipeline quality gas.

[2] Columbia Gas System Proposes as of September 1974 to use Illinois coal.

Source: FPC, 1975b, National Gas Survey, Vol. I, Chap. 10, Table 10-5 abundant resource base for coal, as compared to petroleum, coal-based synthetic natural gas is considered a more likely substitute for Arctic Gas than petroleum-based synthetic natural gas. Therefore, the following analysis of environmental impacts considers impacts of coal-based plants. The environmental impacts of mining needed to provide feedstock for producing SNG need not be repeated.

The environmental residuals for the production of high Btu gas by coal gasification as estimated by Hittman (1974-75) are given in Table 8-32. The Lurgi process is the only one being considered for commercial operation at the present time and in the following analysis, is the only one discussed. Further information and discussion of environmental residuals can be found in the University of Oklahoma report, "Energy Alternatives--A Comparative Analysis," 1975.

Air Quality--Air emissions are produced from several by-products streams. Most are from combustion of fuels in the plant boiler and sulfur recovery plants. Stack gases from the boiler are cleaned with an electrostatic precipitator and wet scrubbing system. Environmental impacts of coal combustion were discussed earlier.

The air pollutants that would be produced by high-Btu gasification of Northwest coal using the Lurgi process for the Btu equivalent of the gas that could be transported by the Alaska Natural Gas Transportation System at full capacity (1695 trillion Btu's per year) would be:

(Tons per year)

Particulates	NO_x	SO_x	Hydrocarbons	CO	Aldehydes
3475	130,345	9475	1270	7238	495

The above calculations are based on estimates in the University of Oklahoma (1975) report, Table 1-46. Emissions would be higher if central or Appalachian coal were used and for any of the processes other than the Lurgi system.

Water Quality--A plant with 60 percent efficiency and synthesizing 250 million cubic feet per day of high Btu gas would emit 160 billion Btu's per day of waste heat. Most of it would be transmitted to the atmosphere through the use of cooling towers. Wet towers would require 20 to 35 million gallons per day to replace water lost by evaporation. In regions where water is scarce, all process waste water and impounded runoff, amounting to about three million gallons per day, would be treated and used for cooling tower make-up. All blow-down streams would be collected and sent to evaporative ponds. If this procedure is followed, water pollutants (including thermal pollution) may be considered to be nil for the Northwest coal (Univ. Oklahoma, 1975).

In areas where water is not recycled, waste water treatment would be required. Untreated waste water from the Lurgi process would contain 15,900 parts per million of ammonium sulfide, 600 parts per million of suspended solids, 9,960 parts per million of phenols, and 1,100 parts per million of oil. Treatment would require three stages of tar-oil-water separation, filtration, phenol recovery, ammonia recovery, and activated carbon scrubbing.

Table 8-32 Summary of high-Btu gasification residuals

Process	Water	Air (tons per 10^{12} Btu's coal processed)					Solids (tons per 10^{12} Btu's)	Total Land (acres)
		Particulates	Nitrogen Oxides	Sulfur Oxides	Hydrocarbons	Carbon Monoxide		
HYGAS	(Recycled or treatment to meet standards	3- 7	60- 68	6-63	1	3.5	3,700-6,500	330
BI-GAS		3- 5	54- 63	14-81	1	3.0	3,800-6,800	330
Synthane		13-15	100-115	10-52	2	5.0	3,800-6,600	330
Lurgi		2- 4	73- 77	6-37	1	4.0	3,700-5,300	330
CO_2 Acceptor		3	38	62	0.5	2.0	8,600	330

For replacing both West Coast pipelines at full capacity, values would be multiplied by 904. For replacing Canadian Arctic Gas Pipeline at full capacity, values would be multiplied by 1695. For replacing Northern Border Pipeline at full capacity, values would be multiplied by 1318. (See Table 8-1, pages 5 and 6 for estimated pipeline capacities, delivery dates and Btu equivalents for the Arctic Gas System.)

Source: Hittman, 1975: Vol. II, Table 2 and associated footnotes. University of Oklahoma, 1975.

Land Quality--Land requirements are estimated by assuming 165 acres fixed land for coal storage, preparation, and gasification plant facilities and an additional 165 acres for evaporation ponds to handle waste water streams. For 18 Lurgi high Btu gas process plants assuming a primary efficiency of 57.3 percent using Western coal, the land required to produce the Btu's equivalent to that of the gas to be transported by the Alaska Natural Gas Transportation System at full capacity (1695 trillion Btu's per year) would be about 4270 acres. Site preparation and plant erection would have environmental effects the kinds, importance, and magnitude of which would depend on the site selected.

The quantity of solids to be disposed of from high-Btu gasification facilities is a major factor in environmental impact. It is primarily dependent on the ash concentration in the feed coal. For a high-Btu gasification facility using Northwest coal, 3,700 tons of material is generated for each trillion Btu's of coal processed. For the Btu equivalent of the Alaska Natural Gas Transportation System at full capacity (1695 trillion Btu's per year), this would be 6,271,500 tons of material (primarily ash). In addition to ash, the CO_2 Acceptor process requires disposal of dolomite. For the Btu equivalent of the Alaska Natural Gas Transportation System, the amount of spent dolomite would be about 5,424,000 tons per year. Solids to be moved and stored as a result of SNG production would amount to about 10 percent of the tonnage of coal mined.

References

Further information on synthetic natural gas may be found in the following references, which are cited in full in the list in Section 8-F-12, References, of this volume: FPC, 1975b; Hittman Associates, 1974-75, Vol. 2, 1975; U.S. Dept. Interior, 1973b; U.S. Dept. Interior, BLM, 1973, 1975c; U.S. Dept. Interior, Office of Coal Research, 1972; U.S. Geol. Survey, 1974; and Univ. Oklahoma, 1975, chaps. 1 and 3.

8-E-5. Hydroelectric Power

Present installations represent a large portion of the most attractive hydroelectric sources in the United States. Nearly half of the capacity is in Washington, Oregon, and California. About 90 percent of the conventional horsepower capacity currently under construction is in the Pacific States. About two-thirds of new capacity consists of additions to existing developments and one-third is at undeveloped sites.

As of May, 1974 the existing capacity could generate about 886 x 10^{12} Btu, though most plants are increasingly used to meet peak demands rather than continuous generation. In 1970 the annual operating factor was about 55 percent, but 20 percent is typical of many new sites. Projected additional capacity through 1983 would raise the equivalent energy available annually to about 965 x 10^{12} Btu, and proposed developments in the following decade might add another 5 percent.

Most present effort in the field of hydroelectric power is in pumped storage. This consumes more energy than it generates; it has an economic advantage in making energy available for peaking times.

It is apparent that the possible increase in capacity of conventional hydroelectric power could not substitute for more than a few percent of the gas which might be delivered through the Alaska Natural Gas Transportation System.

Because an increase in hydroelectric power is not considered a feasible alternative to the proposed gas pipeline, the environmental impact of such an increase is not discussed here.

References

Further information on hydroelectric power may be found in the following references, which are cited in full in the list in Section 8-F-12, References, of this volume: FPC, 1971, Vol. 4, p. IV-1-73 and 1-81, 1972, 1973, 1974; NPC, Comm. on U.S. Energy Outlook, 1973b; U.S. Dept. Interior, BLM, 1973; and Univ. Oklahoma, 1975, chap. 9.

8-E-6. Geothermal Energy

Tapping of a natural heat source in the earth to obtain steam and hot water is a novel method of producing energy for man's needs. Although some hot water and a limited amount of steam have been used for centuries, use of this source for generation of electric power is a new and growing technology. Resource base and exploration techniques are still developing, but it is apparent that most potential sources are in the western United States, as shown in Figure 8-13.

It is estimated that if use of geothermal energy increases as planned, by 1985 it may account for about 1 percent of the U.S. electricity capacity (Univ. Oklahoma, 1975, chap. 1). It is not a feasible energy alternative to the Alaska Natural Gas Transportation System within the time frame of that project. Therefore, aspects of the environmental impacts of geothermal energy are not discussed here although detailed discussions on the subject are given in a report on The Geothermal Leasing Program (U.S. Department of Interior, 1973a) and in a 1975 U.S. Geological Survey Circular on geothermal energy resources (White and Williams, 1975).

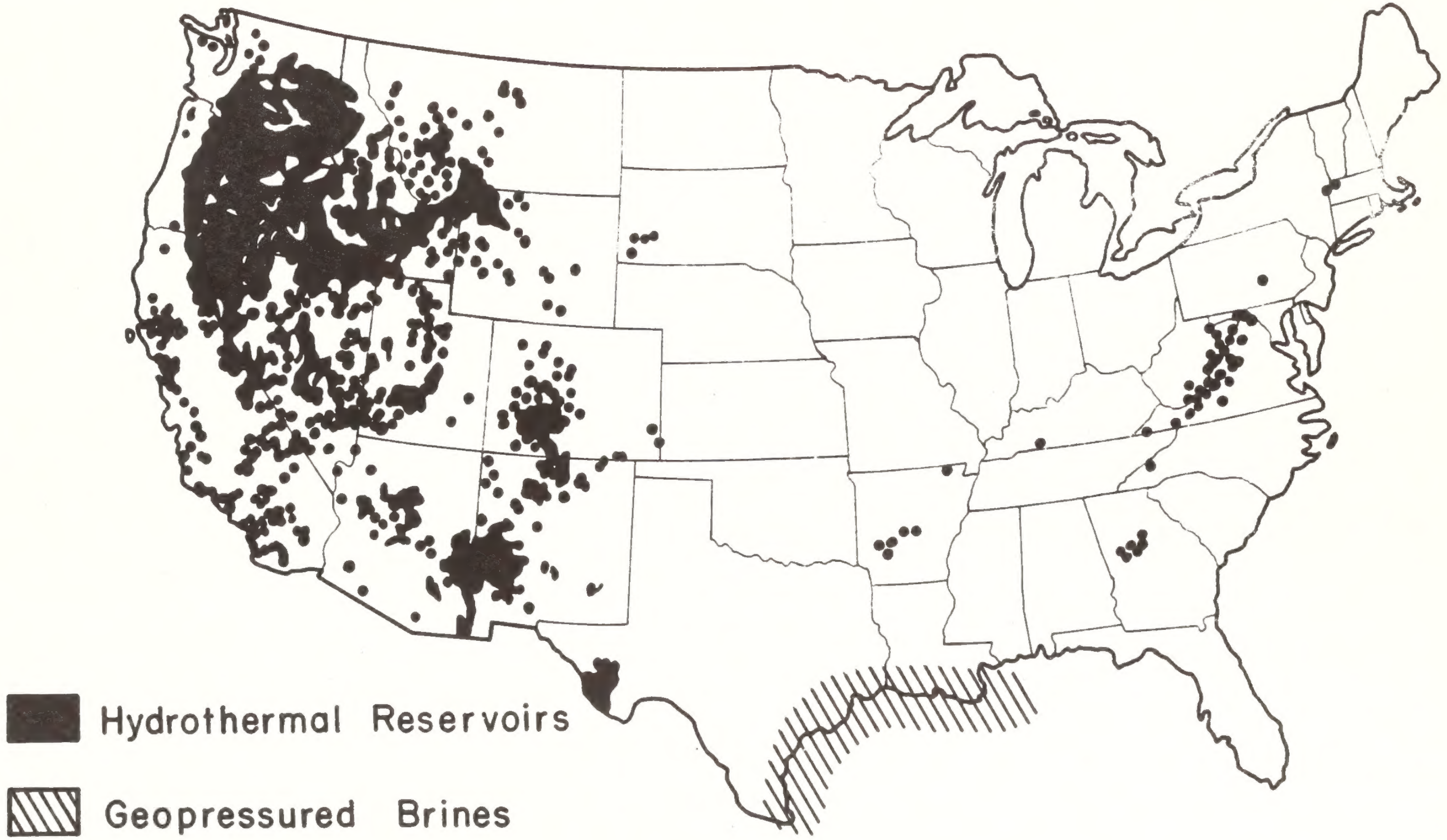
References

Further information on geothermal energy may be found in the following references, which are cited in full in the list in Section 8-F-12, References, of this volume: Axtmann, 1975; Barnea, 1972; Cambel, 1964; Colp, 1974; Ellis, 1975; Grossling, 1973; Jacoby and Paul, 1974; Kruger and Otte, 1973; Muffler, 1973; Rex and Howell, 1973; U.S. Dept. Interior, 1973a; Univ. Hawaii, 1974; Univ. Oklahoma, 1975, chap. 8; White, 1973; White and Williams, 1975; and Wilson, H.M., 1973.

8-E-7. Nuclear Energy

A marked increase in the use of nuclear energy in the future is anticipated as a partial solution to the present United States energy problems. Use of atomic fuels for generating electric power would extend other energy resources, free the finite valuable fossil fuels for other uses, and help to control increasing fuel costs, particularly in areas distant from coal mines or gas and oil fields (Bethe, 1976; Guccione, 1975a).

A forecast of nuclear power growth by the Office of Planning and Analysis of the U.S. Atomic Energy Commission, part of which is now included in the Energy Research and Development Administration (ERDA), projected that, in the most likely case, nuclear generating capacity would be expected to increase from 14,000 Mwe in 1972 to 132,000 Mwe in 1980 and to 1,200,000



Source: DOI, 1973: Vol. 1, p. II-17.

Figure 8-13 Distribution of U.S. geothermal resources

Mwe by the year 2000 or to increase in supplying U.S. energy demands from 1 percent in 1972 to 15 percent by 1985 and 30 to 40 percent by the year 2000 (Nininger, 1973).

Figure 8-14 indicates the corresponding uranium requirements for the most likely case through the year 2000 with the introduction of breeder reactors in 1986 and an 0.30 percent enrichment plant operating tails assay.

Plutonium would be assumed to be recycled in 25 percent of the reactors in 1977, 50 percent in 1978, 75 percent in 1979, and 100 percent from 1980 through 1985, when the recycle would drop off sharply with increased use of plutonium in breeder reactors. If the breeder reactor were introduced in 1990, the annual requirements at the end of the century would be 20 percent higher.

Figure 8-15 contrasts past production levels and projected future annual requirements with the projected annual uranium demand for the most likely case reaching a level of almost 120,000 tons of U_3O_8 per year in 1990 and increasing at a slower rate through the year 2000 because of the introduction of the breeder reactor in 1986. The rate of production needed in 1990 would be about six times the peak rate achieved in the major expansion of uranium production for defense purposes in the 1950's.

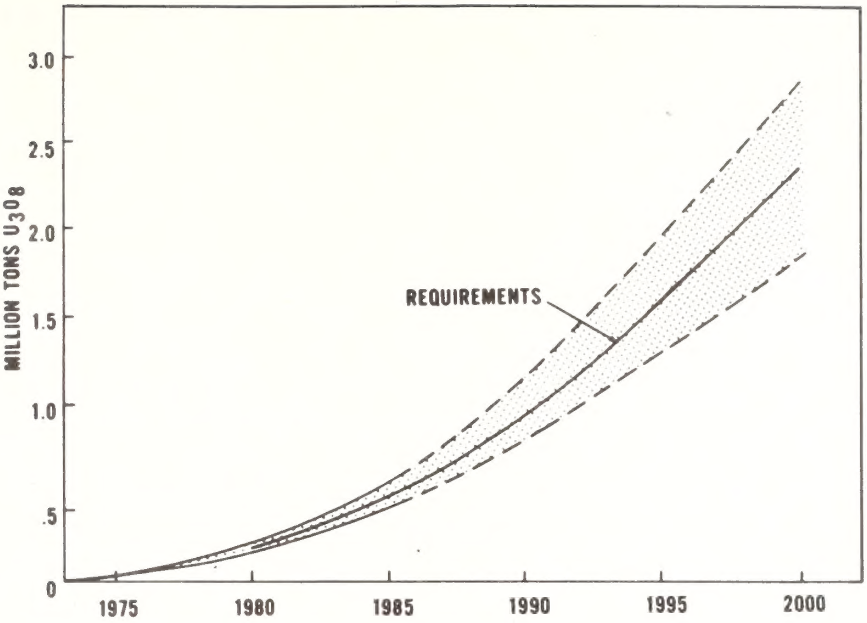
Resource Base

The U.S. Atomic Energy Commission, part of which is now included in the Energy Research and Development Administration (ERDA), has developed estimates of two types of uranium resources. "Reserves" refers to known deposits that can be economically produced at a given market price. "Potential resources" refers to additional uranium that may exist in unexplored extensions of known deposits or in undiscovered deposits within or near known uranium areas. These estimates do not represent the total uranium resources of the U.S. because other uranium areas undoubtedly exist and will be discovered in the future. However, discovery of new deposits may become increasingly difficult and expensive, after the more easily discovered and higher grade deposits are depleted.

Each resource category is also qualified by market price. Estimates at lower prices are more precise because they are based on better data from industry exploration, which has focused on lower price reserves. (Future inflation may lead to increases in all the prices of U_3O_8 used in this study, which was made in 1973).

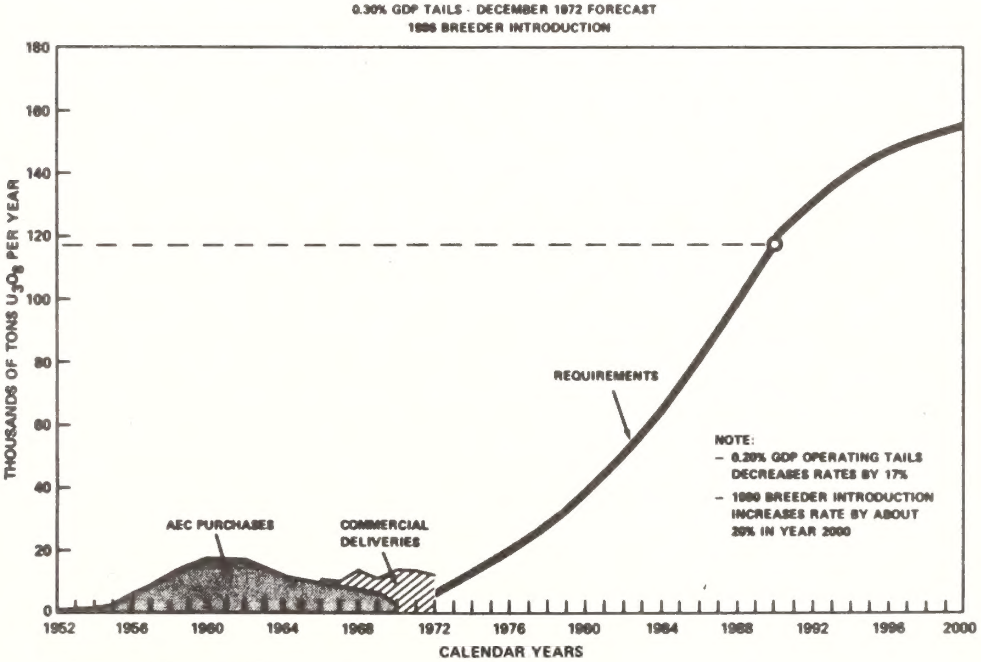
Of reserves of U_3O_8 at $8 per pound, about 50 percent is found in New Mexico, 35 percent in Wyoming, 5 percent in Texas, 3 percent in Colorado, and 3 percent in Utah. The remainder is scattered throughout western United States. As of the beginning of 1973, AEC estimates that $10 reserves of U_3O_8 in conventional deposits in western U.S. (including $8 per pound U_3O_8 reserves) were 337,000 tons. Potential resources of U_3O_8 in western U.S. were an additional 450,000 tons at $8 and 700,000 tons at $10. In 1972, approximately 42 percent of U_3O_8 production came from New Mexico, 33 percent from Wyoming, 7 percent from Colorado, and 6 percent from Utah.

Adequacy of uranium reserves depends on the resource base and time frame being considered. A large gap between long term uranium requirements and resources is shown if resources are confined to the $8 per pound potential resources, $10 per pound reserves, $10 per pound potential resources, and so on. If shorter term demand is considered, reserves of $8 per pound would about equal the next 10 to 11 years' requirements.



Source: Nininger, 1973.

Figure 8-14 Cumulative U.S. uranium requirements 0.30% GDP tails, 1986 breeder introduction



Source: Nininger, 1973.

Figure 8-15 Annual uranium deliveries by domestic producers and projected U.S. requirements 0.30% GDP tails - December 1972 forecast - 1986 breeder introduction

Figure 8-16 shows uranium resources at different prices, while Table 8-33 shows uranium production, reserves, and potential.

Latest figures released by the U.S. Geological Survey at a uranium conference in December 1975 showed a U.S. annual production of 12,000 tons of uranium ore, 600,000 tons of known reserves, and one million tons of undiscovered but probable reserves (U.S. Geol. Survey, 1975b; O'Toole, 1975).

Although uranium at prices up to $15 per pound may find a market in light water reactors in the future, the effort to develop the capability to produce such low-grade ore will not begin until there are indications of a market at that price. The uranium content of $15 resources ranges from 0.10-0.12 percent U_3O_8 compared to 0.20-0.22 percent for $8 resources. Therefore, almost twice as much ore must be processed to produce an equivalent amount of uranium. Depending on the characteristics of lower grade deposits, much more than twice as much material may be displaced. Thus, industry would have to at least double its materials handling capacity to use the lower grade deposits.

Incremental Production

The following table gives the amounts of nuclear energy that would be required to replace the gas that would be transported by the proposed Alaska Natural Gas Transportation System in 1985, based on the premise that all the gas would be used to generate electricity.

Electrical Generation by Nuclear Fuels*

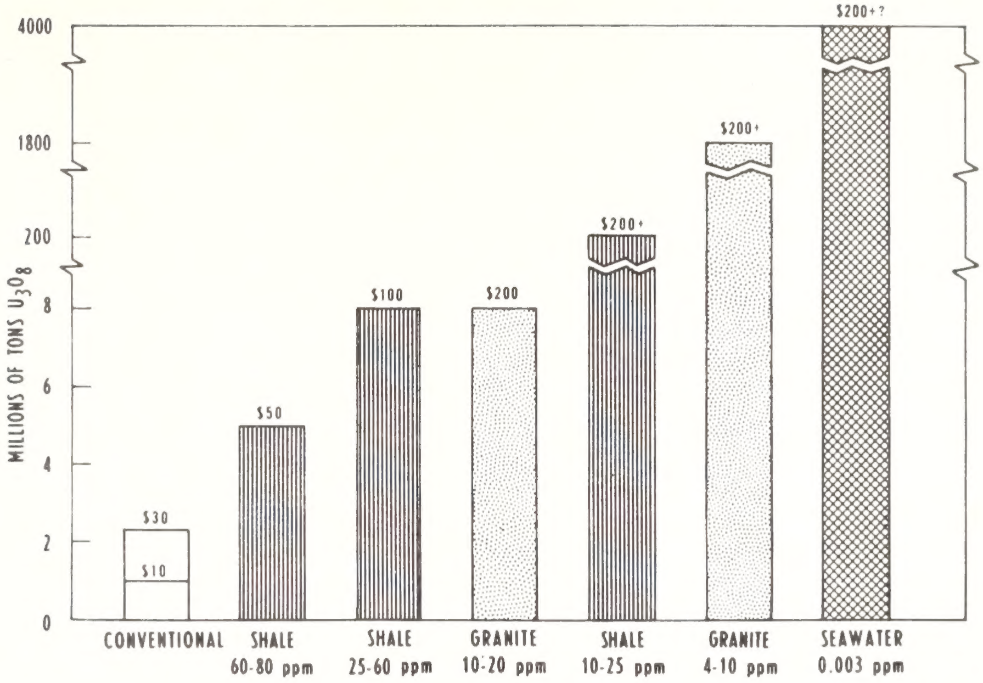
(billions of kilowatt hours (Kwh x 10^9) per year)

Year	Alaska and Canadian Arctic	Los Angeles and San Francisco Pipelines	Northern Border Pipeline
1985	497	386	264

*For conversion factors, see Appendix III.

The electric power supplied by the Alaskan and Canadian portion of the Alaska Natural Gas Transportation System in 1985 would be 497 Bkwh corresponding to 23,000 MW assuming a 40 percent plant efficiency and 100 percent loading. Thus, it would take about 23 1000-MW units to supply the equivalent energy and, on the basis of 3 units to a plant, about 8 plants would be required. For the two west coast segments, the 386 Bkwh would correspond to 18,000 MW assuming a 40 percent plant efficiency and 100 percent loading and, with 3 1000-MW units per plant, would require about 6 plants to supply the equivalent energy. On the same assumptions of 40 percent plant efficiency, 100 percent loading, and 3 1000-MW units per plant, for the Northern Border section, the 264 Bkwh would correspond to 12,000 MW and 4 plants would be required to supply the equivalent energy. A total of 18 plants would be needed to supply the 53,000 MW of nuclear power capacity required to replace the gas which would be supplied by the entire Alaska Natural Gas Transportation System.

The development of nuclear energy represents an important advance in the electric power industry. The predominant nuclear system used in the United States is the uranium dioxide fueled, light water moderated and cooled nuclear power plant. Research and development are being directed



Source: Nininger, 1973.

Figure 8-16 U.S. uranium resources at $10 to $200+ ? per lb. U_3O_8

Table 8-33 Uranium production to date, reserves, and potential compared to requirements

Tons U_3O_8

	1948-1972 Production	Cut-off Cost	Reserves	Potential	Total	Total Reserves and Potential
Ambrosia Lake, New Mexico (the largest U.S. uranium district)	67,000	$ 8	54,000	30,000	151,000	84,000
		$15	97,000	59,000	223,000	156,000
Other New Mexico	30,000	$ 8	80,000	189,000	299,000	269,000
		$15	148,000	395,000	573,000	543,000
Wyoming	47,000	$ 8	98,000	90,000	235,000	188,000
		$15	190,000	265,000	502,000	455,000
Other U.S.	100,000	$ 8	41,000	141,000	282,000	182,000
		$15	85,000	281,000	466,000	366,000
Total U.S.A.	244,000	$ 8	273,000	450,000	967,000	723,000
		$15	520,000	1,000,000	1,764,000	1,520,000

Required estimate 1972-2000---2,400,000 or 16 Ambrosia Lake deposits and 10 times the production to date (Source: Nininger, 1973).

toward other types of reactors, notably the breeder reactor and fusion reactors.

As of mid-1975, nuclear energy was generating about 8 percent of the Nation's electricity. At the end of 1973, nuclear power generated about 5 percent of the Nation's electricity. However, about half of the electric power capacity under construction is nuclear powered. At present, the United States has 55 plants producing nuclear power, another 63 under construction, and 125 on order to be built presumably by 1985 (O'Toole, 1975). Progress in development of nuclear power has been set back by delays in licensing, siting, environmental constraints, manufacturing and technical problems, and regulatory difficulties. Future capacity will be influenced by the availability of plant sites, plant licensing considerations, environmental factors, nuclear fuel costs, rate of development of the breeder and fusion reactors, and capital costs. In order to meet future uranium requirements, an immediate increase in exploratory drilling activity would be required.

Capital costs of nuclear power plants have increased in the past few years. The AEC (now part of ERDA) developed a method to estimate costs for a specific power plant on the basis of a reference case cost. A detailed cost model is selected and modified using data input for the specific project, such as plant type and location, beginning and start-up dates, and rate of interest during construction. The model case may be broken down into over a hundred cost accounts, each of which can be adjusted separately. This procedure was used to develop the following estimates for the base capital cost of a 1000-MW pressurized water reactor reaching commercial operation in 1980.

Capital Estimates for a 1000-MW
Pressurized Water Reactor for Operation in 1980

($ million)

1.	Land	1
2.	Structures and site facilities	38
3.	Reactor/boiler plant equipment	59
4.	Turbine plant equipment	68
5.	Electric plant equipment	16
6.	Miscellaneous plant equipment	5
7.	TOTAL DIRECT COST	187
8.	Contingency allowance	12
9.	Spare parts allowance	1
10.	Indirect costs	49
11.	TOTAL MID 1972 COST	249
12.	Escalation to start of construction*	---
13.	TOTAL AT START OF CONSTRUCTION	249
14.	Interest during construction	63
15.	Escalation during construction*	99
16.	TOTAL AT COMMERCIAL OPERATION	411
17.	Allowance for cooling towers	20
18.	Allowance for near-zero radwaste system	4

19. Allowance for S_2 removal system	---
20. TOTAL COST AT COMMERCIAL OPERATION IN 1980	435

*Escalation rates are 5 percent/year for equipment and materials and 10 percent/year for site labor.

(Source: Olds, January 1973).

Most currently operated and planned nuclear plants use light-water reactors, in which heat energy created in nuclear fission is removed by circulation of water through the fuel core to generate steam that turns the turbine generators to produce electricity. Planning, licensing, and construction lead time for nuclear power plants involves a minimum of 6 to 8 years.

Eight high-temperature, gas-cooled reactors are also completed or on order. These use helium circulating through the fuel core to boil water for steam that turns the turbine generators. All these reactors are of the burner type which use less than 2 percent of the available energy from the uranium they burn. Breeder reactors, which produce more nuclear fuel than they consume, such as the liquid metal fast breeder reactor, are not expected to be available for commercial use until the mid-1980's. Breeder reactors could use more than 60 percent of the total energy of the uranium (Seaborg and Bloom, 1970; Holdren, 1975; Finch, 1975). Thermonuclear fusion reactors are not expected to be a commercial reality much before the year 2000. It is possible that some incremental reactors could be high-temperature gas-cooled reactors, which have a higher thermal efficiency and subsequently less waste heat problems. However, the number which could be built is considered to be small enough to be disregarded in the overall analysis.

Because of the long lead time required in the construction of all types of nuclear power plants, builders of plants used to substitute for the gas from the Alaska Natural Gas Transportation System could only use current technology. Thus the plants considered as replacements would be light-water reactors of either the boiling water or pressurized water types.

Considering the rapid growth in use of nuclear power through the year 2000, which is expected by industry and government sources, and the delays caused by long lead construction time and increasing difficulties of builders in meeting, on time, the continuous upgrading of the licensing and safety standards stipulated for reactor construction, it is doubtful that even the few additional reactors required as a substitute for the gas of the Alaska Natural Gas Transportation System, let alone those already under construction or planned, could be built within the required time frame for either the Arctic gas replacement or for future nuclear power development in the next 25 years.

Environmental Impact

The significant impacts of uranium mining and milling, power plant operation and construction, transportation of spent fuel and waste materials, reprocessing plants, and radioactive waste material storage are discussed in terms of their effects on air, water, land, and plant and animal life. Information on the environmental impacts of a breeder reactor can be found in the Atomic Energy Commission's Environmental Statement, "Liquid Metal Fast Breeder Reactor Program," Volumes II and IV, WASH-1535, December, 1974b.

Uranium Mining and Milling--The construction and operation of additional nuclear generating plants would require additional mining and milling of uranium ore to supply the fuel elements for these plants. Uranium mining and milling in the United States is concentrated in New Mexico, Wyoming, the Colorado Plateau, and south Texas. Because most known and potential reserves are concentrated in New Mexico, Wyoming, and the Colorado Plateau, the incremental mining and milling activity would be expected to occur there. In 1970, 53 percent of production came from underground mines, with most of the remainder coming from open pit mines. The ratio of production between underground and open pit mines is expected to be basically maintained over the next several decades.

In underground mining through the 1950's, excessive exposure to radioactive daughter products of radon, a radioactive gas produced by spontaneous decay of uranium, resulted in a high incidence of lung cancer. However, the recommended annual exposure limits have been vastly reduced in the past decade. By maintaining these lower limits, the incidence of lung cancer in underground uranium miners would be expected to be reduced to a level not significantly higher than that of the population as a whole.

Uranium mining is largely concentrated in relatively isolated areas distant from large population centers and urban areas. Nonetheless, it does have an adverse aesthetic impact in the areas in which it occurs, as a result of the removal of the vegetative cover. Also, air quality in the immediate area could undergo some temporary reductions because of this removal of ground cover and the associated dust from vehicle and equipment movement. Waste rock is piled on the ground, changing the surface texture and accumulating extra overburden. Open pit mines would require considerable acreage, reducing (depending upon location) the suitability of that area for other land uses such as grazing, wildlife, and some outdoor types of recreation. For underground mining, the extraction of deeper ores would tend to require some accumulation of waste rock dump areas. Planning for sequential land uses, followed by the reclamation of mined land and the backfilling of mined-out stopes with waste rock, could substantially reduce these land use problems.

Because of the low concentration of U_3O_8 in uranium ore, milling the ore produces considerable amounts of tailings. These tailings contain radioactive products and, therefore, must be contained in well constructed tailings dams to prevent the erosion and leaching, which could result in the radioactive products entering surface and ground water systems. The specific adverse effects of these on the overall health of biota are not fully known; current evidence, however, does indicate increasing concentrations through upward stages of food chains. The technology for designing and constructing safe tailings dams does exist and is being used to prevent erosion and leaching and to retain harmful mill effluents at present levels of production.

Because of their low level radioactivity, mill tailings would be unsuitable for subsequent use as fill material where human exposure might result. They would also be a hostile environment for nearly all biota. To minimize erosion in above-ground storage, tailings should be covered with gravel or dirt upon which a vegetative cover could be established. Above-ground storage would require considerable land area, displacing such land for other potential uses. In the future, increasing amounts of tailings might be used to backfill mined-out stopes and open pits.

Power Plant Construction and Operation--As an example of the land requirements, assuming an average of three 1,000-MW units per site, construction of 53,000 MW of additional nuclear power capacity by 1985 to replace the entire Alaska Natural Gas Transportation System assuming a 40 percent plant efficiency and 100 percent loading, would require 18 additional plant sites (less if some units were added to existing plants). Under current siting criteria, these would be located some distance from population centers. Assuming 500 acres per site (based upon an exclusion area of one-half mile radius around each plant), 18 new plants would require a total of 9,000 acres, an area from which most other uses would be excluded.

Depending on the capacity of the transmission lines, which would be required if nuclear energy were to substitute for energy produced from other fuel development, the transmission line right-of-way would use 10-15 acres per mile of line. Certain types of development such as residences would be restricted but such land would still be available for purposes such as recreation. The additional transmission lines would have an adverse aesthetic impact by disrupting some scenic vistas.

Construction of the plants would present some short-term environmental problems such as the erosion of excavated materials. Special measures could be taken to prevent such erosion and subsequent siltation.

Operations of the nuclear plants would generate considerable amounts of waste heat. Light-water reactors have lower thermal efficiencies, around 33 percent compared to 40 for new fossil fuel plants. Given this difference in efficiency and assuming that fossil fuel plants usually release around 15 percent of their waste heat directly into the atmosphere, a light-water reactor would release approximately 50 percent more waste heat into its cooling water than a fossil fuel plant of similar size. Effects of this waste heat would depend on the cooling method used and the location of the plant. Assuming a 15-20°F temperature rise, a "once through" method of direct discharge of the water into the original water source would require 270-360 billion gallons of water per year for a 1000-MW plant.

The effects of thermal discharges would depend in part on the size of the body of water receiving this heated water. The effects along ocean sites, the Great Lakes, and very large rivers or other large water bodies likely would be modest because the heat would be more readily dispersed and more easily avoidable by aquatic species. Along smaller lakes and rivers, or in bays with limited circulation, higher water temperatures could produce fish kills, interfere with fish reproduction, disrupt food chains, decrease dissolved oxygen content, drive out desirable aquatic species, and encourage the growth of undesirable algae which may speed up eutrophication within the limits of the affected areas. However, sometimes the heat could be used for agriculture and other beneficial uses.

Although the use of wet cooling towers to remove heat by evaporation into the atmosphere does not pose the problems of adverse thermal effects, water vapor from the cooling operations could still have substantial effects on local haze, fog, cloud, and ice formation. Chemicals released in the cooled water or evaporated plume could also have adverse effects on downstream and downwind biota.

Use of cooling ponds produces less evaporation than wet cooling towers, but haze, fog, cloud, and ice formation would still occur during periods of sub-freezing temperatures. The ponds require additional acreage (an estimated 1,000-2,000 acres per 1,000-MW unit). These may have recreational uses but would also displace previous land uses.

Nuclear power plants, unlike fossil fuel plants, would not emit the usual products of combustion such as particulates, sulfur oxides, and NO_x. Hence, they would not generate the air pollution problems stemming from or requiring control measures for such emissions. They would produce radioactive emissions, of which release must be strictly limited to avoid adverse effects to the health of humans and other biota.

In the normal operation of the incremental nuclear generating units, very small amounts of radionuclides would be discharged in the cooling water and gaseous plant effluents. If present standards were maintained and enforced, limiting radioactivity exposure of an individual at the plant boundary to 1 percent of the individual maximum dose allowed, the effects of the amounts released would likely be negligible, for the average additional annual dose which the affected population would receive would be three or four orders of magnitude less than the average level of natural radiation exposure.

Operation of nuclear plants would pose some risk of accidents, even though nuclear plants would be designed to minimize an accident or its adverse effects by using a "defense-in-depth" principle. This would include designing and constructing plants to prevent accidents, to contain the effects of accidents should they occur, and to siting reactors away from areas of high-population density. Plants would be designed to withstand a design basis accident (DBA), defined as the worst malfunction considered to have a probability of occurrence high enough to warrant corrective action. For light water reactors, the worst DBA considered would be usually a major rupture in the cooling system. The maximum radiation dose which could be received at the site boundary if such an accident occurred, would be estimated for some plants not to exceed the annual dose resulting from exposure to natural radioactivity.

Operation of many nuclear plants over an extended period of time could be considered to pose some risk of a catastrophic accident, despite the very small probability of occurrence. Fear of such accidents, because of the accidents at the Fermi reactor and five other reactor sites since 1952 (Novick, 1969; Fuller, 1975; and Time Magazine, 1975b), has led to a slowdown in all phases of reactor licensing and construction until the safety problems can be solved satisfactorily. This holds true despite the recommendations of the General Accounting Office that funds should be allocated to speed up study on the breeder reactor program.

Transportation--The nuclear fuel cycle would require the transportation of radioactive materials by truck or rail at many stages, such as transporting spent fuel elements from reactors to reprocessing plants or high-level wastes from reprocessing plants to storage sites, thus posing a potential hazard of considerable magnitude. Existing transportation regulations and cask designs have been developed to insure that if accidents did occur in transporting these materials, no radioactivity would be released into the environment. For the transport of spent fuel and high level wastes associated with an incremental 53,000-MW capacity, a very small number of accidents would be expected to occur during a 25-year operating life.

Fuel Reprocessing and High Level Waste Storage--Spent fuel assemblies from reactors would be partially cooled at the plant site and then transported to fuel reprocessing plants where usable nuclear fuel materials would be recovered and radioactive wastes, separated. For 53,000 MW of additional capacity, this would require either the construction of two or three new processing plants or the expansion of existing plants. The former alternative would require two or three new sites, entailing a complete displacement of present land uses.

While radioactive emissions during reprocessing would be greater than those produced during normal power generation, the estimated dose to the affected population would still be two orders of magnitude below natural levels. Thus the impact of emissions is not expected to be significant, although the chronic effects of such low level radioactivity are not fully known.

Present regulations require the conversion of liquid high-level waste from fuel reprocessing to a stable solid material within five years after separation in the fuel reprocessing step. The waste must then be encapsulated and shipped to a Federal repository within ten years of its production. Thus, operation of the 53,000 MW of incremental nuclear capacity would lead to the production of about 2915 cubic feet of high-level wastes annually.

Because of their high concentrations of radioactive nuclides with very slow rates of decay, these waste materials must be totally isolated from the biosphere for hundreds or thousands of years in order to avoid serious adverse effects to all living organisms. The concept of storage in salt beds has been termed satisfactory by a National Academy of Sciences advisory committee. Engineered facilities in selected geologic environments and capable of insuring permanent isolation from the biosphere have been considered as an alternative to salt bed storage. Pilot studies conducted for several years and continuing should determine the acceptability of specific sites.

As an interim measure for storing solidified wastes from commercial operations, the Atomic Energy Commission, part of which is now under ERDA, announced plans, in May 1972, for the design and construction of a Retrievable Surface Storage Facility (RSSF). This facility would be designed to store these wastes safely for as long as a century, if necessary. As the name implies, the RSSF program would include having these stored wastes retrieved and moved to permanent storage facilities as soon as such facilities are established. The goal is to have permanent disposal methods available in the next two to three decades.

At present ERDA plans further study of several promising geologic formations other than bedded salt, including the study of specific promising sites, to bring the knowledge of these other formations up to the same level as that of present knowledge of bedded salt. The goal of this further study is to permit comparative evaluation of these formations and selection of the optimum formation or formations for pilot plant operations. In the late 1970s, the study and evaluation program is expected to permit a decision and a request to Congress for authorization and appropriation for a specific geological disposal pilot plant at a specific site.

References

Additional information on nuclear energy is given in the following references, which are cited in full in the list in Section 8-F-12, References, of this volume: Bethe, 1976; Finch, 1975; Fuller, 1975; Guccione, 1975a; Holdren, 1975; Nininger, 1973; Novick, 1969; NPC, Comm. on U.S. Energy Outlook, 1973b; Olds, 1973; O'Toole, 1975; Resources for the Future, 1971; Seaborg and Bloom, 1970; Time Magazine, 1975b; U.S. Atomic Energy Comm., 1973, 1974a, 1974b; U.S. Dept. Interior, 1973a; U.S. Dept. Interior, BLM, 1973; U.S. Geol. Survey, 1975b; and Univ. Oklahoma, 1975, chaps. 6 and 7.

8-E-8. Summary of Environmental Impacts Associated with Alternative Energy Sources

Various domestic energy resources which might be alternatives to the Alaska Natural Gas Transportation System in terms of energy equivalents have been discussed or mentioned briefly in the preceding sections. Any increase in resource extraction will have adverse environmental impacts in the areas in which it is mined, processed, and used.

It is important to note that in considering alternatives the effect is to transfer some environmental problems from one area to another. To cite only one point as an example, permafrost problems connected with a buried pipeline and compressor stations in northern Alaska are a serious consideration. By not building the pipeline these problems are avoided. However, the impact of producing equivalent amounts of energy in the conterminous United States, again to cite one point for comparison, would be that the rate of coal mining will have to be greatly increased. No matter where the additional energy resources are tapped, there will be impact on the environment.

Coal and to a lesser extent nuclear energy are the only alternative sources discussed in some detail. Oil shale and geothermal energy are certain to make contributions to the nation's future energy resources, but are less likely to be able to substitute in major amounts for the energy of Alaska natural gas. Each of these four sources has different degrees of impacts. Fuel efficiency is shown in Table 8-34. The statements in the following text which discusses the impact of each of these four sources under various topics is meant to be objective in calling attention to the magnitude of some of the impacts.

Climate

Coal and Synthetic Natural Gas--Environmental problems connected with coal are related to its extraction and cleaning, transport, and conversion. Coal conversion can consist either of direct combustion of coal, liquefaction, or gasification. Gasification will produce synthetic natural gas (SNG), and environmental problems associated with coal extraction, cleaning, and transportation will also apply to SNG.

Assuming that National Ambient Air Quality Standards are observed, the climatic effects of coal processing would be small. Even assuming that the total Alaska Natural Gas Transportation System supply would be replaced by coal, this addition to coal use (71 million tons per year) would increase the total domestic coal production by slightly over 10 percent if coal energy is used by direct combustion, and by approximately 18 percent if the Arctic gas is replaced by coal-derived SNG.

Local humidity changes and sporadic fog could occur in the proximity of coal burning or coal gasification plants because of the steam produced.

Oil Shale--Assuming that National Ambient Air Quality standards apply, climatic effects of oil shale mining and processing would be similar to those for coal. The main activity in oil shale development will be in the rich deposits of the Green River Formation in Colorado, Utah, and Wyoming. Studies of the Piceance Creek Basin in Colorado (FEA, Project Independence, Oil Shale, Nov. 1974) for different weather regions have shown that the potential of Piceance Creek oil shale could be developed without violating EPA air quality standards. The release of larger quantities of water, if

Table 8-34 Estimated ultimate fuel efficiency

Fuel and Use	Delivered efficiency	X	Utilization efficiency	=	Ultimate efficiency
Coal (bituminous):					
Central heating, hand fired	93.0	X	45.0	=	41.8
Central heating, stoker fired	93.0	X	55.0	=	51.1
Water heating, pot stove	93.0	X	14.5	=	13.5
Oil:					
Central heating	81.0	X	63.0	=	51.0
Water heating, 100 gallons per day	81.0	X	50.4	=	40.8
Natural gas:					
Central heating	93.0	X	75.0	=	69.7
Water heating, 100 gallons per day	93.0	X	63.7	=	59.2
Electricity:					
Central heating, resistance	[1]17.0	X	95.0	=	[2]16.1
Central heating, heat pump	[1]17.0	X	226.0	=	[3]38.4
Water heating, 100 gallons per day	[1]17.0	X	92.2	=	[4]15.6

[1] FPC's Bureau of Power estimates this at 27 percent.

[2] FPC's Bureau of Power estimates this at 26 percent.

[3] FPC's Bureau of Power estimates this at 61 percent.

[4] FPC's Bureau of Power estimates this at 25 percent.

Source: Gas Engineers Handbook, Fuel Gas Engineering Practices, 1965; FPC, 1975b, National Gas Survey, Vol. I, Chap. 8, Table 8-4.

this could be obtained, in the mostly arid areas would not be expected to result in any significant climatic changes.

Nuclear Energy--Nuclear plants are located mainly at large bodies of water because of the amount of cooling water required. For each megawatt of power produced, two megawatts have to be dispensed into the cooling medium. A "once through" method of water cooling of a 1000-MW plant would involve 270-360 billion gallons of water per year with a temperature rise of 15-20°F. This water when discharged into the lake or ocean could cause local formation of fog, haze or ice. An alternative method of transferring the heat to the atmosphere via wet cooling towers or cooling ponds would result in similar after effects.

Geothermal Energy--Development of geothermal energy would affect local climatic conditions because of release of large amounts of steam and waste heat into the atmosphere. A geothermal plant typically requires 20-25 lb/hr of steam for each Kwh output. Of this, approximately 75 percent is released as vapor to the atmosphere after power extraction and 25 percent is condensed to water and is either released to streams or reinjected. Thus a 1000-MW plant would release approximately 8000 tons of steam per hour. The same plant would reject to the atmosphere, via cooling towers, approximately 3600 MW of heat. Local climatic effects of these effluents would be a change in the air temperature lapse, possible temperature inversions and possible cloud formation. The magnitude of the effects would depend on local topographic and meteorological conditions.

Topography, Geology, Soils

Coal and Synthetic Natural Gas--The topography in the coal mining area would be affected by the excavation and the large amount of solid waste produced. In surface mining the amounts of solids varies greatly (see Table 8-24), depending on the overburden thickness, from less than a ton per ton of coal to over 30 tons per ton of coal. Assuming an average value of ten tons of waste per ton of coal, the replacement of the Alaska Natural Gas Transportation System by surface mined coal would involve approximately 710 million tons per year of waste disposal. For underground mining the solid waste is less and it is mainly in the form of sludge removed from contaminated water but even then it could range up to 3 million tons annually.

The undesirable topographic effect of waste and surface mining include: creation of massive piles of spoils, destruction of vegetative covering, drastic reshaping of the terrain, sliding of sludge, and blockage of streams. As a consequence of underground mining, subsidence over abandoned mines affects the topography and creates hazards.

To reduce the impact on topography, some State regulations are in force, and Federal regulations are in process of legislation. Reclamation includes redistribution of top soil, backfilling, grading, replanting, and other operations. Any reclamation activity will increase the cost of coal and reduce the coal output per acre of land.

Similar problems will exist for coal-derived synthetic natural gas (SNG) except that they will be greatly magnified because about 50 percent more coal has to be mined due to conversion inefficiency to provide gas of equivalent total Btu value.

Oil Shale--Oil shale development would affect the topography of the local area. This is particularly true for the most advanced technology, surface retorting, where shale mined underground is brought to the surface for processing. *In situ* retorting, which would reduce the amount of spent shale on the surface, is still in the early development stage.

The amount of solid waste generated from oil shale processing is very large and includes overburden which must be removed to expose the shale, and the spent shale after oil is extracted. For underground mining of sufficient oil shale to replace the Arctic gas approximately 30,000 tons of overburden would be accumulated annually. The total spent shale to produce in Btu's the equivalent amount of oil (about 800,000 barrels per day) would amount to approximately 400 million tons per year. It is estimated that 90,000 tons of solid waste could cover a land area larger than 25 acres to a depth of one foot; at this depth about 4,400 acres would be covered annually.

This total solid waste is of the same order as that created for surface mined coal. It would be greater if the oil shale had to be surface mined. Therefore, the topographic changes would be at least the same or greater than that of coal mining. A land reclamation process even when fully implemented would further increase water demands in the areas of oil shale.

Nuclear Energy--As noted, nuclear plants are usually located near or at large bodies of water. In addition the plants must be located in geologically stable areas. The topographic impact of a nuclear plant would not be greater than any other plant of comparable output.

Mining of uranium either underground or on the surface results in environmental problems similar to those of coal mining, but on a much smaller scale.

Geothermal Energy--The impact of geothermal energy exploration with vapor-dominated systems would be small and would be confined mainly to well drilling and access roads. In water-dominated systems, there would be additional effects of waste water residuals and the possibility of land subsidence because of fluid withdrawal. If fluid withdrawal takes place near an active fault, it could possibly trigger earthquakes or land movements.

Water Resources

Coal and Synthetic Natural Gas--The impact on water resources is twofold with additional water required for coal extraction, cleaning, and conversion and stream and ground water contaminated by process effluents.

Surface coal mining consumes 16 gallons of water per ton of coal, and underground mining consumes 36 gallons of water per ton of coal (FEA, Project Independence, Coal, Nov. 1974). For the 71 million tons estimated to replace the energy that could be transported by the Alaska Natural Gas Transportation System, the additional volumes of water required would be major.

The gasification plant for production of SNG would require still more water, between 6,000-10,000 gallons per minute for a plant producing 250 MMcfd of gas. To replace the gas transported, 18 such plants would be required consuming 84,000-140,000 gallons per minute or an average of 67 billion gallons per year.

It would require a separate study to determine whether such water requirements could be accommodated as an addition to the already formulated plans for increased coal usage. It is obvious that continually increasing water demands from all national sectors will limit the rate of energy growth.

Water pollutants associated with surface and underground mining of coal are shown in Tables 8-24 and 8-26 respectively. Suspended solids form the greatest part of water pollutants by far, ranging from a fraction of a percent of coal extracted to over 1 percent. For a modern mining operation most water used in the process is recirculated, but once the concentration of suspended solids reaches 20 percent, a blow-down of water to the surface is necessary. The suspended solids can be precipitated in a controlled system from the water to deposit some of the solid waste volume discussed before; if controls are not enforced, waste water enters surface streams and ground water. Contamination of local waters can also occur by run-off from solid waste piles. The largest runoff occurs in Appalachia where rainfall is about 20 inches per year and would cause serious silting problems affecting all aquatic life. In the southwest where there is little runoff because of limited rainfall, the silting problem is minimal.

Production of SNG from coal introduces additional water contamination problems. Contaminated waters from a coal gasification process, where water is used both as process cooling and scrubbing fluid, contains phenols, creosols, tars, ammonia, cyanides, and other chemicals. The total amount of these contaminants may be over 0.6 percent. Release of such contaminants into streams and ground water will have a deleterious long-term effect on aquatic life and terrestrial animals. Technology for water treatment, such as, ion exchange, reverse osmosis, absorption, filtration, and chlorination, is available to bring contamination within acceptable limits before water discharge into the environment. Because the coal gasification process requires such large amounts of water, the process of water treatment and subsequent sludge disposal requires careful planning.

Oil Shale--Oil shale mining and processing involves large amounts of water. It was estimated (FEA, Project Independence, Oil Shale, Nov. 1974) that with underground shale mining, a 50,000 barrels-per-day plant will require about 8700 acre-feet per year of water (1 acre-foot--326,000 gallons) of which almost half would be used for disposal of spent shale. Very little of the water could be used for recycling and the waste water produced will be saline, with dissolved solids, organic compounds, and suspended solids.

The source of water for a large oil shale operation is uncertain. Present forecasts for oil shale development to replace the dwindling domestic reserves of domestic oil call for production of 50,000-100,000 barrels-per-day in 1980 and 750,000-1,600,000 barrels-per-day in 1990. Replacement of Arctic gas by oil shale (approximately 800,000 barrels per day) would use up almost all of the proposed oil shale production in 1990, leaving only a small excess to balance the reduced supply of domestic oil. Water requirement for oil shale processing in 1990 would be approximately 140,000 acre-feet per year. For comparison, all future available water in Colorado, Utah, and Wyoming is approximately 360,000 acre-feet per year.

Nuclear Energy--Nuclear energy production requires substantial amounts of water for uranium mining, processing, plant operation, fuel reprocessing, and storage.

Mining of uranium in amounts to satisfy the consumption of a 1000-MW plant would involve pumping from mines 123 million gallons of water annually and probably would result in lowering local groundwater levels. If this water contains suspended solids and settling ponds were not used, these pollutants would enter local water supplies. The processing of the fuel, which includes crushing, leaching, washing, and separation, for a 1000-MW plant would use 65 million gallons of water annually. The liquid tailings left from the processing would be approximately 260 million tons annually. Uranium enrichment would require another 11-12 billion gallons per year. Finally, there would be a water requirement for power plant cooling of 270-360 billion gallons per year.

Contamination of the water during fuel processing would be mainly with inorganic salts and suspended solids, and would be comparable to that of coal mining discussed above.

Geothermal Energy--In the vapor- or water-dominated geothermal energy sources, problems are not with water consumption, but with its disposal. A typical steam-dominated well produces 150,000 lb/hr of steam, and a water-dominated well produces 400,000-500,000 lb/hr of water of which approximately 20 per cent flushes into stream. The remaining water is either reinjected or purified for other uses. Geothermal waters are usually saline. Imperial Valley brine, for instance, consists of 250,000 ppm of dissolved solids, primarily Si (silicon), CaCO, NaCl, and B (boron). About 50 billion gallons of brine per year would be required for a 1000-MW plant in Imperial Valley, and this would contain 50 million tons of solids. Reinjection of such water may be the only feasible economical solution but unless reinjection is done in cemented wells at sufficient depth, there is the possibility of groundwater contamination. Water condensed from a steam-dominated system is cleaner but should not be released into the environment without processing because it contains ammonia, boron, and sulfates, detrimental to aquatic life.

Vegetation

Coal and Synthetic Natural Gas--Coal mining, particularly surface mining, would result in destruction of vegetation, the total depending on the amount and type of disturbed land area (see section on Land Use). Even with a reclamation plan in operation, restoration of vegetation would require several years. Disposal of solid waste, which is mostly alkaline, may affect drainage patterns and would delay the restoration process. Usually vegetation would be affected in an area greater than the mine area because runoff from accumulated waste would disperse pollutants.

SNG derived from coal would affect more vegetation because about 50 percent more coal has to be extracted for equivalent Btu's and additional facilities would be required for coal gasification. A SNG plant for 250 MMcfd would require about 900 acres of land and, to replace the gas to be transported by the Alaska Natural Gas Transportation System, 18 such plants would be required. Cumulative effects of coal mining and gasification plants would depend on plant locations. If a plant is at the mine, the combined effect would be less than if the plant is separated. It is uncertain what the effects of pollution which might be released from production of SNG would be on vegetation.

Oil Shale--Oil shale development would affect vegetation in the local areas primarily by its destruction in the mine and plant sites. Development at 800,000 barrels per day would require up to 60,000 acres over a forty year period for mining, processing, waste disposal, utility corridors, urban needs and associated facilities.

Existing vegetation would be eliminated around all these places and vegetation changes would take place on the entire surface area involved. Revegetation effects would follow the initial land disturbance and, if successful, a continuing level of disturbed surface at about 16,000 acres would be associated with a considerable time requirement to re-establish shrubs and tree cover in the pattern of existing vegetation.

The restoration would include, among other steps, of replacement of productive soil material, addition of fertilizers, formation of small terraces or basins for retention of natural runoff water, planting of seeds or seedlings or native species, and addition of irrigation water. Leached spent shale placed to a depth of several feet on spent shale should enable plant growth similar to natural conditions, although in some areas it might be limited to salt-tolerant species.

Nuclear Energy--The mining area for uranium, which in open pit mining may extend to 3000 acres, would be devoid of vegetation. Restoration schemes could reduce the area of destruction to about 1000 acres and maintain it at that amount through the life of the mine. The area required for a power plant site would amount to 500 acres for a 3 1000-MW unit plant. Replacement of energy that would be transported by the Alaska Natural Gas Transportation System by nuclear energy would require approximately 18 such 3 1000-MW-unit plant sites, which would involve an area impact on vegetation of 9,000 acres. This is comparable in area to the impact of oil shale extraction and processing.

Geothermal Energy--Vegetation around a geothermal power plant and access roads would be destroyed by normal operational and maintenance activity by spillage or storage of contaminated water or waste, and by venting of hot steam and water.

Wildlife

Coal and Synthetic Natural Gas--Unlike pipeline construction, coal mining, whether surface or underground, is a continuing process. The pollutants generated, and the noise, in particular of strip mining, would have a primary effect of disturbing the local wildlife probably forcing it to abandon the area.

Other impacts are often those effects on wildlife which are not caused by mine or plant operation but by such secondary factors as increased human population and greater transportation activity. Any of these factors may have a direct impact on wildlife, causing it to change its behavior rapidly or die, or the impact may have indirect effects by modifying the habitat and changing food source in such a way that population dynamics are affected.

As noted, production of SNG may cause similar but increased problems because of more extensive mining operations and the additional effects of gasification plants.

Oil Shale--The regional deleterious effects of oil shale development on wildlife would be significant and would be caused by: reduction in water quality by such factors as siltation, increased salinity, and accidental spill of toxic substances; reduction in water supply through water table drawdown; increased urbanization and traffic; increased noise from construction and operation; vegetation removal; and the filling of 15 to 30 canyons with spent shale. Big game such as mule deer would be reduced by a minimum of 10 percent and animals such as elk, moose, bear, and mountain lion would disappear entirely from the region directly or indirectly affected by oil shale development. Small animals and rodents would decrease in population because of the increased competition for food and water. High quality fish, such as trout and whitefish, being more vulnerable to change with changes in the quality of water, would be reduced or would disappear; stocking and other management steps could be taken to mitigate the effect.

Nuclear Energy--The impact of nuclear fuel mining, processing, and power plant operation on wildlife would be similar to the impact of coal production and processing.

Geothermal Energy--Wildlife would migrate away from the vicinity of a geothermal plant because of the noise. The venting of steam produces a high frequency noise which could be abated to a degree with suitable silencing equipment but which would still be intolerable to most of the wildlife in a radius of about a mile from the plant.

Ecological Considerations

Coal and Synthetic Natural Gas--By the virtue of pollutants generated, coal mining operations affect locally terrestrial, estuarine and marine ecosystems. The transport of pollutants in water, soil, and air through an ecocycle (air/water/soil - flora - fauna - human) and long-term effects are not yet well understood but some of the deleterious effects of certain pollutants are already known. Pollutants oxidizing in water lead to oxygen deficiency, water eutrophication and decline in fish population; sulfides in air lead to formation of sulfuric acid; oxides of nitrogen affect photosynthesis. Other potential effects of construction and operation on ecosystems include: disruption through excavation, hydrologic disruption through channel modification; modification through increased siltation, decrease in the available oxygen, change in the stream thermal regime, eutrophication of lakes and streams, addition of toxins into waters; withdrawal of large quantities of water for processing and cooling.

The SNG impact will be similar but greater in magnitude than mining. In addition, new problems will result from pollutants generated in gasification.

Oil Shale--The impact of oil shale development on ecosystems will be similar to that of an expanded coal mining program.

Nuclear Energy--Of special importance is the impact of plant cooling water which is heated 15-20°F before being discharged back to the source. Long-term effects of this warmer water on marine or aquatic life are still being studied. Short-term impacts observed during the last 10-15 years do not appear significant in naturally warm waters but may be severe in cooler waters.

Geothermal Energy--Impact on aquatic and estuary life in particular can be expected because of potential contamination of streams and ground water with traces of water pollutants such as boron and ammonia from vapor-dominated systems. In water-dominated systems high salinity of reinjected brines may lead to potential contamination of ground waters. Acute and chronic effects of such pollutants on terrestrial and aquatic biota need to be investigated.

Economic and Sociological Factors

Coal and Synthetic Natural Gas--An increase in coal production to replace the Arctic gas either by direct combustion or by gasification would require an accelerated coal expansion program. The average coal production per man-day is 35 tons for surface mined coal and 11 tons for underground mining (FEA, Project Independence data on coal, 1974). Assuming that the 71 million tons of coal per year required to replace the Arctic gas would be mined, in the present day proportion of 50 percent underground and 50 percent on the surface, such a project would involve a work force of more than 20,000, all skilled labor. In addition a number of mining engineers would be required. At present their number in the U.S. is inadequate and in 1973 some 75 mining engineers were imported to fill industry's needs.

SNG plants will employ up to 1000 people and this employment level will indirectly support up to 5000 people in supportive business and civil services.

The socio-economic problems resulting from industrial expansion of coal would be similar to those experienced in boomtown conditions. Local hyperurbanization would require rapid construction of housing to alleviate proliferation of substandard mobile temporary housing; integration of new workers into the locality is needed; and provision for medical, school, and other services in advance of construction should be planned.

To provide the needed mining equipment for expanded coal extraction and plant equipment for SNG processing, federal priorities would have to be established in allocation of raw materials and production incentives.

Increased transportation facilities for coal would be required. Approximately two-thirds of coal presently produced is transported by rail, though the trend in recent years has been against railways. Coal carriers would need incentive to commit more resources to carrying coal and reversing this trend.

Capital investment in opening new coal mines to extract the additional 71 million tons per year would be at least 1.7 billion dollars, in 1973 dollars. One SNG plant of 250 MMcfd would involve investment of over 400 million dollars. For 18 plants calculated to replace the Arctic gas this would involve an expenditure of 7.2 billion dollars which is about equal to the expected cost of the Alaska Natural Gas Transportation System. As an additional cost, pipelines would have to be built to distribute SNG to receiving points in the existing pipeline network.

Oil Shale--A rapid rate of increase of oil shale development would create problems similar to those of the rapid increase in coal production. Employment requirements for a 50,000 barrel-per-day plant (which is 1/16 of that replacing the Arctic gas) at the peak of construction would be approximately 1200 people and an operating line of approximately 1400. This is basic employment and does not include any supporting services. The rapid influx of people would lead to hyperurbanization in the large but sparsely developed areas of Utah, Colorado, and Wyoming. Experience has shown (FEA, Project Independence, Oil Shale, Nov. 1974) that if rapid population growth rate exceeds ten percent, existing institutions, including the local labor market and local government structures, become inadequate and break down. Development of oil shale to replace the Arctic gas by 1985 would exceed that critical growth rate. Hyperurbanization results in degradation of the quality of life; in reduction of productivity and profitability; and in impairment of local government functions.

Capital investment would approximate that of increased coal mining.

Nuclear Energy--Development and construction of nuclear power based on Light Water Reactors or Pressurized Water Reactors is well established technology. However, manpower requirements for construction of a nuclear power plant might be higher than that of a coal gasification and oil shale retorting facility. The manpower required to operate a nuclear power plant is lower than that required for the same output of coal gasification and oil shale, both of which are still in pilot plant stage. Consequently the long term local socio-economic impacts of nuclear plants should be less acute than those of oil shale or coal gasification plant expansion.

Public acceptance of widely proliferated nuclear plants and issues of public safety in case of a major failure are still unresolved.

Geothermal Energy--A geothermal plant fed by perhaps a hundred wells will yield only on the order of several hundred megawatts of power. This will limit the labor demand in any one locality. Furthermore the absence of complex energy conversion facilities will also limit the manpower required. These factors will mitigate the socio-economic effects of geothermal energy development. Hyperurbanization will not arise, but there will be a shift in land use from agriculture towards industry, changes in local zoning ordinances, and some changes in the profiles of employment.

Land Use

Coal and Synthetic Natural Gas--Land required for surface and underground coal mining is shown in Tables 8-24 and 8-26 respectively. The area lost to surface mining varies considerably depending on the thickness of coal seams and type of mining and control by enforced restoration. For a controlled area, surface mining would require on the average 500 acres per million tons of coal per year. If half of the 71 million tons of coal per year required to replace the energy of the Arctic gas was produced by stripmines, the land requirement would be approximately 18,000 acres per year.

In underground mining there is no difference in yearly land requirement between controlled and uncontrolled development and, in fact, for the uncontrolled case very little of the surface would be permanently affected. However with control of water and air pollution, land must be provided for construction of purification plants and for disposal of sludge. Table 8-27 shows that the fixed area of land lost during the life of the service would be on the same order on the average as for surface mining. The loss of land does not appear to be significant, particularly if the effect of minerals leaching and runoff can be confined to a small area.

SNG production resulting in 50 percent more coal production would require a proportionally larger land area. In addition land for a 250 MMcfd plant would require about 900 acres of land. For that which would be needed for the 18 plants to replace the Arctic gas, this would amount to an additional 16,000 acres lost for an indefinite period of time.

Oil Shale--Land use for processing about 800,000 barrels per day to replace the Arctic gas would amount to about 60,000 acres (see "Vegetation"). Yearly land use for similar size plants with underground mining is approximately 3300 acres per year, but this value includes land for some of the facilities which would not increase appreciably with time. With restoration proceeding on a continuous basis, the acreage of the disturbed land could be kept at a value of 1600 acres annually. The values quoted above should be considered as average and may vary greatly depending on whether mining is underground or surface, whether processing is in situ, surface retort, or combined, and the thickness of shale seam. Land could not be used for pasture or agricultural needs for several years even when restored.

Nuclear Energy--Land used by uranium mining, nuclear power plants, and access roads was discussed under "Vegetation"; this land would be unusable for other purposes. The amount involved for plants totals 9,000 acres but is not considered significant.

Geothermal Energy--A geothermal plant of 1000-MW output would require 3,000-5,000 acres of land of which only seven to ten percent would be used directly for facilities. This land would not be usable for other purposes for the life of the plant estimated at 25 years or even longer. In addition, fluid withdrawal creates the danger of local subsidence in adjoining areas and such subsidence may have far reaching effects. For instance, in the Imperial Valley the irrigation relies on a relatively small gravity head of water and subsidence of only a few feet would affect irrigation of many thousand acres of agricultural land.

Air Quality Change, Noise and Vibration

Coal and Synthetic Natural Gas--In discussing coal-related air pollutants, four distinct aspects have to be examined: surface coal mining; underground coal mining; direct coal combustion; and coal conversion to SNG through a gasification process.

In surface mining, air pollutants are produced from fuel burning in the supporting equipment, coal crushing, and pollutants from the transportation system used. Tables 8-24 and 8-25 show the type and amount of pollutants generated. Oxides of nitrogen (NO_x) and of sulfur (SO_x), carbon monoxide (CO), hydrocarbons, and particulates are the main offenders. Air pollution controls for heavy machinery and stationary power plants are in the process of formulation. The average amount of pollutants from surface mining could be 75 tons per million tons of coal.

Although electric equipment mostly is used for underground mining operations, generation of electricity would generate air pollutants of the categories listed above. Coal crushing, washing and transportation would also generate air pollutants as in surface mining.

Coal combustion creates similar pollutants. CO, hydrocarbons, particulates, and NO_x can be reduced by improvements in furnace design; however, SO_x are a function of sulfur content of this coal. Sulfur oxides can be reduced either by washing coal before burning or by scrubbing flue gas; both methods are now being developed.

Coal gasification would produce air pollutants similar to those of coal combustion with the exception of absence of oxides of nitrogen and the addition of trace metals and gases such as ammonia, cyanides, and chlorides.

Combustion and process control is being developed to reduce the amount of air pollutants to an acceptable level. However, the problem remains of disposal of those pollutants extracted either in liquid or solid form.

Construction equipment and noise of operational plants would have an adverse impact on wildlife and local human populations. The intensity of noise would depend on the sophistication of the silencing equipment installed, and on timing of the most noisy operations, such as drilling and blasting during the peak time of background noise. It is unlikely that even the best silencing equipment would prevent migration of wildlife from the vicinity of the mine or plant but it could mitigate the impact on human population.

Oil Shale--The main air pollutants associated with oil shale mining are particulates, oxides of nitrogen (NO_x) and sulfur (SO_x), carbon monoxide (CO) and hydrocarbons.

For underground mining and surface retorting on the scale of an 800,000 barrel-per-day plant, particulates would be produced at a rate of 600 tons per day, NO_x at 8.5 tons per day, SO_x at 8.5 tons per day, hydrocarbons at 13.6 tons per day, and CO at 78 tons per day. The NO_x, SO_x, and CO pollutants are higher for surface mining because of the extensive use of heavy equipment that burns fossil fuels.

The effect of construction and operation noise would be similar to that of coal mining and processing.

Nuclear Energy--In normal operation of a nuclear plant, the radiation levels to which the operating areas are exposed are kept well within the "safe" doses determined by the Nuclear Regulatory Commission (formerly part of AEC). Air pollution associated with mining is mainly from the fossil fuel burning, construction, and auxiliary equipment and is similar to that encountered in coal surface and underground mining.

The noise in mining and milling is also similar to that of coal mining. The operating noise level of a nuclear plant is low and comparable to that of closed cycle steam turbines.

Geothermal Energy--Gases associated with geothermal steam include hydrogen sulfide, ammonia, boric acid, carbon dioxide, carbon monoxide, methane, and others. Of those, hydrogen sulfide poses the greatest toxicity hazard as well as nuisance odor. It is heavier than air and under inversion conditions can accumulate in local areas. Ammonia is lighter than air and will not accumulate readily near the ground. Unless pollutants are controlled, a vapor-dominated 1000-MW geothermal plant would release about 40,000 tons of hydrogen sulfide and 10,000 tons of ammonia per year.

Because there is no combustion, particulates, NO_x, and SO_x, which are predominant in coal and shale oil combustion, are absent. Consequently the overall impact on air quality of a geothermal plant would be less than that of a fossil fuel plant.

Noise from steam vented to the atmosphere is of high frequency and does not attentuate as rapidly as the noise of drilling and construction equipment. A muffled testing well will produce a noise of 65 decibels at 1500 ft. distance from the well. For comparison an air drill at the same distance, although starting from a higher noise level, will produce only 55 decibels. Because some steam wells are always venting, the noise of an operating multiwell facility would be considerable.

Health and Hazards

Coal and Synthetic Natural Gas--There are two health and hazard problems arising from expanded coal operations. One is the hazard of pollutants continually discharged into the environment, even with some type of controls in existence, and the other is a hazard caused by a malfunction of the system or its pollution controls.

One difficulty arises in the assessment of health and hazards resulting from coal mining and coal conversion because no data are available as yet on long-term health effects of such pollutants as SO_x, NO_x, and particulates. Much more research would be needed to determine what these long-term effects are and what environmental standards would be needed to minimize such effects. The pulmonary problems associated with coal mining (black lung disease) are known.

The malfunction hazards which are experienced in the underground mines in the form of gas explosions and cave-ins are well known. With any accelerated coal extraction program, emphasis on mine safety would be needed. Explosion of a SNG plant is possible in view of the flammability of the gas produced. Failure of water or air emission controls could result in release of vast amounts of pollutants into the environment. Such occurrences could be minimized by redundancy of the key components, by containment of pollutants in case of an accidental release, and by safety training programs for employees involved in operations.

Oil Shale--The pollutants from an oil shale operation are similar to those generated by coal mining and coal conversion and the comments made about coal apply also to oil shale. Safety measures to prevent mine explosion, subsidence, and fire in the processing facilities also would be similar. Because oil shale processing is a new industry with limited experience, safety measures and environmental controls operations have not yet been fully developed.

Nuclear Energy--The short- and long-term effects of radiation on human health have been subjects of studies for over 20 years. Radiation safe dose standards were established and plants are being built to comply with those standards. However, even though it is remote, a possibility always exists of a major reactor failure which could release excessive doses of radiation into the environment. The full effect of such malfunction has not yet been established.

Another problem is transportation of nuclear fuel or radioactive waste and of long-term storage of that waste. With proliferation of the nuclear power plants these problems will gain in significance, and improved safety measures must be provided to protect man and his environment.

Geothermal Energy--One of the hazards associated with geothermal wells is a well blowout. One type of blowout occurs when hot fluid moves up the well during drilling, and the other, when fluid leaves the well, finds another permeable channel, and emerges with disruptive force. Results of a blowout may be bodily injury to workers, noise nuisance, and air and water contamination from uncontrolled discharge. One well which blew out in The Geysers area resisted plugging efforts and kept blowing for several years.

8-F. Alternative Transportation Systems

Alternative modes of transportation are compared to the Alaska Natural Gas Transportation System. The systems considered here are Land routes, including dense-phase and methanol pipelines, railway, and monorail; Marine routes, including ice-breaking tankers and submarines; Air routes, including airplanes, Helifloats, and dirigibles; Conversion of natural gas to other energy sources, including electrical generation and transmission; and possible Alternative combinations of various modes. Because of its greater complexity, one other alternative, a combination of an all-Alaska pipeline-LNG tanker-regasification system, is discussed fully in section 8.2 of this Alternatives volume.

For each system, the discussion includes a description of the system and its required facilities, its feasibility, and its environmental impact. Figure 8-17 shows the routes of the alternative transportation systems. Table 8-35 compares the special facilities required for the various transportation systems with those required in the Alaska Natural Gas Transportation System and the alternative all-Alaska pipeline-LNG tanker-regasification system.

Some of the information used for each alternative system has been drawn from documents submitted by applicants who wish to build the pipeline, to the United States and Canadian governments, as well as from other pertinent U.S. government documents and the scientific literature. These items have been cited in full in the list of references in Section 8-F-12 of this volume.

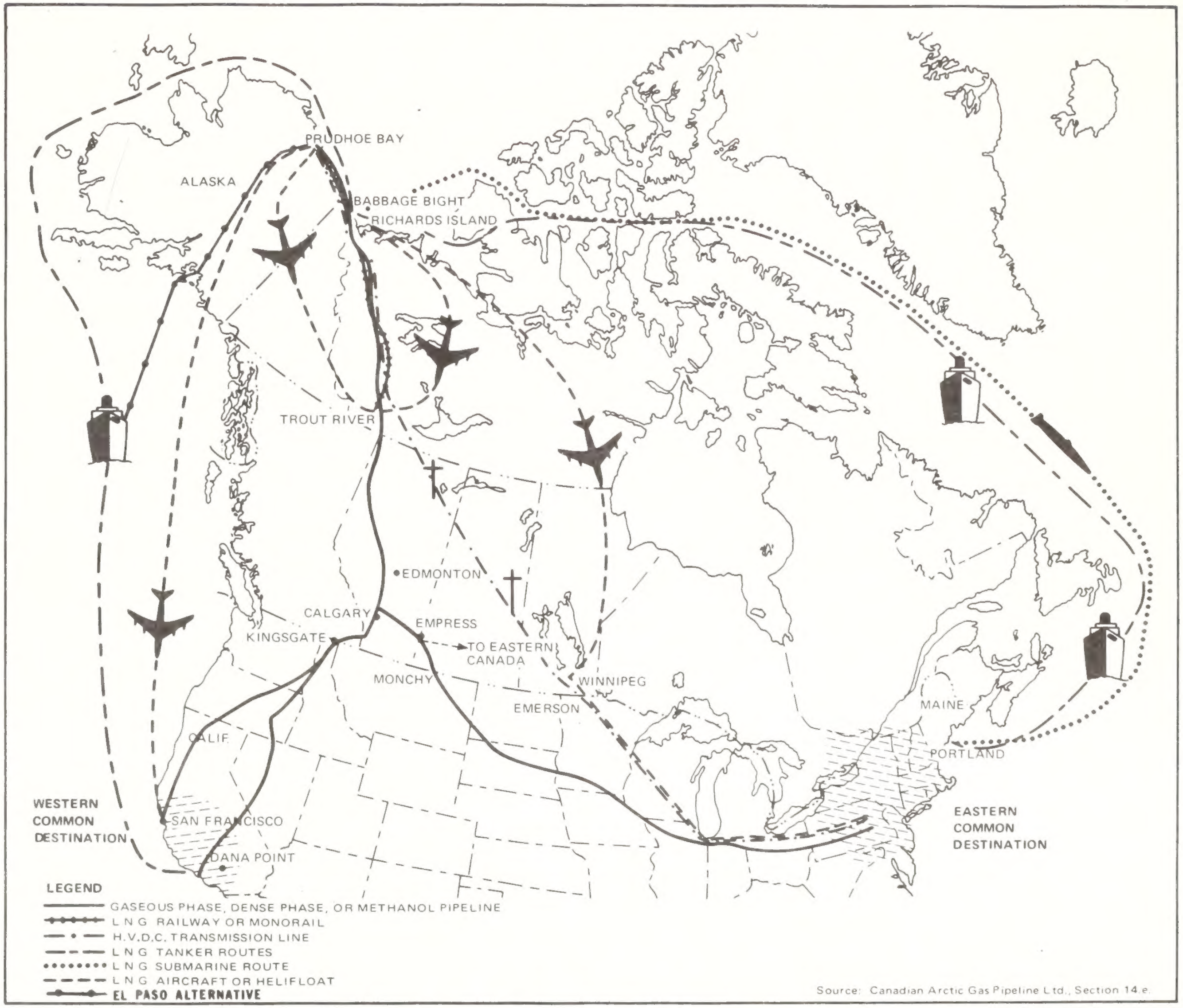
A list of abbreviations used frequently in this section is given in Appendix I.

8-F-1. Dense-Phase Pipeline

Description

Natural gas in the single phase region but exhibiting properties between a liquid and a gas in the -115°F (Fahrenheit) temperature range and at pressures from approximately 400 to 1,000 psig (pounds per square inch gauge) is called dense-phase. Natural gas from Prudhoe Bay, Alaska and Mackenzie Delta, Canada would be converted to this phase in dense-phase plants located near the gas-producing plants. This gas would then be transported by dense-phase pipeline along the Prime pipeline route of the Alaska Natural Gas Transportation System (Figures 1.1.2.2-1 in the Canada volume and 8-17) to Kingsgate on the British Columbia-Idaho border and to Monchy on the Saskatchewan-Montana border, each locality receiving 50 percent. It would be regasified in plants at these two locations and then transported to western and eastern common destinations by conventional gas pipelines. Facilities required for the dense-phase pipeline system would be two dense-phase refrigeration plants, dense-phase pipelines, and two regasification plants (CAGPL, 1974; Jensen and Ellis, 1967).

Each dense-phase refrigeration plant would occupy 50 to 100 acres and be constructed near the gas-producing areas. One plant would be at Prudhoe Bay and the other at Mackenzie Delta, Canada. Incoming natural gas would be turbo-expanded to the 550 design psig operating pressure and the recovered energy used in the refrigeration process. Fuel gas would be removed at this point. The remaining natural gas would be processed by six pretreatment parallel propane-ethane-methane cascade refrigeration strings, which would remove water and carbon dioxide to prevent solidification of these substances under dense-phase conditions. The refrigeration plant would



Source: Canadian Arctic Gas Pipeline Ltd., Section 14.e.

Figure 8-17 Routes for alternative transportation systems

Table 8-35 Comparison of components required in various transportation systems

Transportation Systems	Pumping and/or Compressor Stations (number and acreage)	Refrigeration or Chilling Stations (number and acreage)	Plant Complexes of Various Types (number and acreage)
Arctic Gas Pipeline System	45; 15-20 acres each	34; included in pumping station acreage	none
Dense-Phase Pipeline System	60; 15-20 acres each	16; included in pumping station acreage	2 dense-phase, 50-100 acres each; 2 regasification, size unspecified but probably about 200 acres each
Methanol Pipeline System	45; 29-43 acres each	1 (permafrost area only); probably 5-10 acres	2 methanol, 150-200 acres each; 1 SNG conversion, 200 acres
Methanol Tankers or Submarines	none	none	2 methanol, 150-200 acres each; if converted to gas, 2 SNG conversion, 200 acres each
LNG Use in Marine and Airborne Systems	none	none	2 LNG liquefaction, 100 acres each; 1 or 2 regasification (number depends on system), size unspecified but probably about 200 acres each
Electrical Generation and Transmission	none none	none none	2 HVAC-to-HVDC conversion, at least 200 acres each; 1 HVDC-to-HVAC conversion, at least 200 acres

Source: Canadian Arctic Gas Pipeline Limited (CAGPL), 1974.

contain equipment and facilities to produce its own utilities, including refrigerants, from natural gas. Three turbine generators would provide the electrical power generation while diesel generators would provide emergency and start-up power. Sea water pass-through would be used as a coolant and, based upon a 14°F temperature rise, the sea water circulation required would be about 390,000 gallons per minute. Cooling towers could be substituted for the pass-through system but would add greatly to the cost of the project and require more land.

The design input at the Prudhoe Bay plant would be 2,531 BBtud (Billion British thermal units per day) and the total consumption, 122 BBtud or 4.8 percent of the plant feed. At Mackenzie Delta, the design energy input would be 2,387 BBtud and the fuel consumption, 113 BBtud or 4.7 percent of the plant feed. A permanent labor force of about 300 employees would be required to maintain and operate each plant.

Because of the greater density and relatively low pressure of the dense-phase gas, a dense-phase pipeline could have thinner walls than the conventional natural gas pipeline, resulting in a considerable saving of steel. A common 48-inch diameter pipeline would carry the dense-phase gas from the two northern sources to a point north of Calgary, where the line would split into two pipelines, 38 inches in diameter, to transport the gas to Kingsgate and to Monchy. All the pipelines would have a 6-inch outer coat of polyurethane for insulation and vapor barrier purposes. A comparison of facilities used for this and other transportation systems is shown in Table 8-35. This system would have about 60 pump stations, about 19 more than required by natural gas pipeline, positioned along the Prime pipeline route (Figures 1.1.2.2-1 in the Canada volume and 8-17) and spaced from about 30 to 50 miles apart with an average horsepower of 3,550 in the main pipeline and 2,500 in the southern segments. Although the exact locations and sizes are not specified, the size of the pump stations would probably be from 29 to 43 acres including the 16 refrigeration stations located at every fourth pump station, and having a discharge temperature of -150°F. These would be about equal in number to those for the natural gas pipeline and would be spaced about 125 miles apart in the main pipeline. South of Caroline Junction the flow rate and pipeline diameter would be less, so pump stations could be nearly 300 miles apart in the two southern segments. Total fuel consumption by both on-line pump and refrigeration stations would total about 235 BBtud, resulting in an energy efficiency of 95 percent.

Required regasification plants of unspecified size would be constructed at Monchy and Kingsgate and each would process 50 percent of the total system throughout. Eight parallel regasifiers would heat the incoming dense-phase gas while a separate one would provide fuel gas to both process facilities and utilities. The plants would be self-contained and generate their own electricity to meet power needs. Energy input is estimated at 2,225 BBtud while fuel for each plant would be about 24.3 BBtud or 1.1 percent of the plant feed. Conventional gas pipeline would carry the gas to its final destinations. Because of the greater energy consumption of the dense-phase gas system as opposed to the natural gas pipeline system, the slightly lower throughputs would result in reduced horsepower and/or wider spacing between compressor stations. Total fuel consumption by these components of the transportation system would be about 164 BBtud. Heat developed during pipeline transport would be removed with aerial coolers equipped with fans and associated with the refrigeration stations.

The dense-phase pipeline system would require about the same number of shutoff valves, gas measuring stations, communications stations, airstrips, helicopter pads, and borrow pits as the natural gas pipeline system.

Feasibility

There is no commercial experience in the building and operation of either the dense-phase refrigeration plants or the regasification plants in Arctic areas. The technology would seem to be straight-forward and, because both plants are scaled versions of existing liquefaction plant facilities, no problems would be anticipated in their construction. A high degree of reliability would be expectable and the same high satisfactory level of technical confidence could also be applied to the compressor and on-line refrigeration stations.

The dense-phase pipeline system, which has not yet been used commercially over great distances, presents several problems regarding the pipe, including field welding, durability of insulation, stress prevention, and frost-bulb formation. These would have to be solved prior to the final design.

Analysis of costs indicates that the total common destination capital cost for the dense-phase pipeline would be about 1.5 times that for the Alaska Natural Gas Transportation System, and the total common destination operating cost would be almost two times greater. The overall efficiency of the dense-phase system would be about 86.1 percent or a loss of 682 BBtud based on an average daily energy of 4918 BBtud delivered by the producers, as opposed to 90 percent and a 489 BBtud loss for the Alaska Natural Gas Transportation System.

Environmental Impact

Because of technological problems associated with development of a dense-phase pipeline system, high cost factors, and lower efficiency, at the present time the dense-phase pipeline appears to be lower in the level of technical confidence and in economic feasibility than the Arctic Gas natural gas pipeline. It is unrealistic to assume that this approach will be pursued. Therefore, only a few potential environmental impacts which are also associated with other alternative systems are considered in any detail.

The environmental impact of the dense-phase pipeline, which would follow the Prime route of the Alaska Natural Gas Transportation System, would be very similar to that system in many of its components and their environmental effects, which have been described earlier in this report in the Canada volume, Section 3 on the environmental impact and mitigating measures of the Canadian section of the Alaska Natural Gas Transportation System. Only additional differences are included here.

The presence of a dense-phase plant at Prudhoe Bay and at Mackenzie Delta would mean that 200 acres of land would be required for each plant in a permanent permafrost area (Péwé, 1975). This would disturb the wildlife in the area because of the noise and dust created by the construction machinery and necessitate shifts in habitat and loss of wildlife in the area to be occupied by the plant complex. To maintain and operate each plant, an estimated permanent labor force of about 300 employees would be required, thus involving additional land for housing and other service facilities to meet their needs. An even larger construction force would require similar facilities but for a shorter period. The socio-economic impacts of such a permanent labor force are often overlooked and stressed insufficiently.

The effects on the marine environment of a 14°F rise in temperature of sea water returned to the Beaufort Sea after use in the plant cooling system have not been studied sufficiently for accurate determinations to be made. There would undoubtedly be some increase in the water temperature and thus some effect on the marine ecology. However, according to an Arctic Institute of North America study (1974), the water of the Beaufort Sea has an average temperature of -1° to -2°C under the ice in winter and of only 0°C or slightly higher in summer when the coast is navigable for about six weeks from late July through early September. The marine life, especially the number of species of fish, is very limited because of the low seawater temperature. Trawl studies show that the warmer adjacent Chukchi Sea has both many more fish and many more species. Thus, a thermal effluent of cooling water with a temperature rise of 14°F, that is, 7.8°C, would not be likely to raise the temperature of the coastal water of the Beaufort Sea any appreciable amount or to have severe detrimental effects on its marine life. If, over a long period of time, the thermal effluent should raise the sea water temperature to above 0°C throughout the year, the number of available desirable fish species in the Beaufort Sea might increase, because the Arctic Institute (1974) reported that certain marine fish species migrated to warmer estuaries or to other warmer waters of the Arctic, including the Chukchi Sea, when the nearsurface water temperature dropped below -1.8°C as it does in the Beaufort Sea. In addition, the coastal waters might become free of ice and navigable for a longer time period than the present six weeks of summer. Improvements in pass-through water cooling systems in the past few years (Krenkel and Parker, 1969; Parker and Krenkel, 1969; Yannacone, 1974) and, especially, the new developments in fish screens and other devices used at both the cooling water intakes and outflows would also give greater protection to fish by preventing their being caught in the intake flow stream inside the plant components and in the mainstream of the rapidly moving warmer outflow. The effect of the rise in temperature on the fish population is not as significant as the possible establishment of a thermal gradient by the plume of warm water. This gradient would have a more profound effect in that it might lead to queueing and migration of fish toward areas where differences in temperature may be less than 0.5°F. Thus the plume could have effects far beyond the immediate area of this change and possibly even beyond the Beaufort Sea.

The only feasible alternative system that could be substituted for the use of pass-through cooling water would be the use of expensive cooling towers. These would not affect the marine life but would still produce fogging problems.

The long range effects on climate of warming part of the Beaufort Sea water by thermal effluents and of continual breaking of the ice pack have not yet been investigated.

The coastal area is also one with a high seasonal concentration of wildlife, particularly staging snowgeese and caribou. Some waterfowl habitats could also be affected by the presence of the plant on the coast.

One socio-economic effect with related environmental impacts not generally stressed would be the presence of an increased permanent labor force on the north slope of Alaska.

Construction of regasification plants at the two distribution points on the Canadian-United States border would involve wildlife disturbances and land requirements similar to those noted above for the dense-phase plants.

8-F-2. Methanol Pipeline

Description

Two plants to convert natural gas to methanol, a liquid alcohol, would be constructed at Prudhoe Bay, Alaska and Mackenzie Delta, Canada, near the producers' gas processing plants. The resulting methanol would be transported by pipeline along the Prime route of the Alaska Natural Gas Transportation System (Figs. 1.1.2.2-1 in the Canada volume and 8-17) to a destination at Delmont, Pennsylvania in the eastern United States (CAGPL, 1974). There the methanol either would be converted to synthetic natural gas and then transported by conventional pipelines to its final destination or used directly as chemical feedstock.

Under the Alaska Arctic and Canadian Arctic proposals (AAGPC, 1974; CAGPL, 1974), the methanol plants would each require about 100 to 150 acres of land. The natural gas feed of 2,259 MMcfd (million cubic feet per day) at each of the two plants would have the same quality as that used in the natural gas pipeline, except that carbon dioxide in the gas as produced would not be removed in the field processing plants, thus resulting in higher methanol yields by adjustment of the carbon-hydrogen ratio.

Natural gas feedstock would be purified to reduce the sulfur content. The stream then would be preheated, mixed with superheated steam, and reacted over a catalyst at high temperature to produce a "synthesis gas" composed of hydrogen, carbon monoxide, and carbon dioxide. After the cooling and compression of this gas, methanol would be produced over a catalyst in a methanol converter, after which the water and low boiling point components would be distilled from the methanol. At the Prudhoe Bay plant, 17 parallel methanol production trains would be needed to produce a total of 76,700 tons or 550,000 barrels or 1,497 BBtud (Billion British thermal units per day) with a total energy consumption of 1,034 BBtud. At Mackenzie Delta, where the gas feed differs slightly in composition, 14 trains would be needed to produce 68,200 tons or 490,000 barrels or 1,331 BBtud with a total energy consumption of 1,056 BBtud. In the synthesis of natural gas to methanol, on the basis of 1 mole of water consumed per mole of methanol produced and considering the relative density of methanol and water, about 300 gallons of fresh water appear to be required for every ton of methanol produced, although according to present current methanol plant patterns, the figure might be nearer 125 gallons (Institute for Energy Analysis, 1974). On the basis of 300 gallons per ton of methanol, the Prudhoe Bay plant would require 23,010,000 gallons of water per day for production of 76,700 tons of methanol and the Mackenzie Delta plant, 20,460,000 gallons per day for 68,200 tons of methanol. For the same tonnage per day but based on 125 gallons of water per ton of methanol, the Prudhoe Bay plant would use 9,587,000 gallons and the Mackenzie Delta plant, 8,525,000 gallons. Because the North Slope fresh water is frozen much of the year, most of the processing water probably would have to be taken from the Beaufort Sea and then be desalinized before being used in the synthesis. Such desalinization facilities would add considerably to the plant costs, an estimated $5.5 million for a 5130-ton plant. If the methanol were carried by submarines instead of by pipeline, as suggested in the U.S. Department of Commerce, Maritime Administration report (1975), their methanol-ballast water could be converted for use in the synthesis and thus eliminate the need for North Slope fresh water. For the initial cooling, if absorption type refrigeration units used the heat from the synthesis procedures, refrigeration costs might be reduced substantially (Institute for Energy Analysis, 1974). Storage equivalent to one day's production would be provided. About 700 employees would be required to maintain and operate each of the two methanol plants.

Because the volume of fluid would be smaller, conventional 36-inch diameter pipeline would transport the combined production from Prudhoe Bay and Mackenzie Delta, amounting to about one million barrels per day, to a common eastern destination with no plan to route any methanol to the west coast. It would be about 4,040 miles long and operate at a maximum pressure of 960 psig (pounds per square inch gauge). A comparison of facilities used for this and other transportation systems is given in Table 8-35. This system would require 45 pumping stations, 5 more than the natural gas pipeline, of 20,000 horsepower each and unspecified size probably between 29 to 43 acres including the refrigeration station, distributed along the Prime route and spaced about 80 miles apart. It would need only one instead of 15 cooling stations, to maintain methanol temperatures of 20° to 30°F (Fahrenheit) through the permafrost zones. (Methanol is a liquid which freezes only at -97.8°C, so it remains a liquid without excessive refrigeration and pressure requirements at temperatures below 32°F in the permafrost.) It would follow essentially the Prime route of the Alaska Natural Gas Transportation System. At its eastern destination in Delmont, Pennsylvania, the methanol would have a heating value of 2,609 BBtud and would be received and stored in conventional tankage on a tank farm with a capacity equal to one day's pipeline throughput. It could then be used directly in its methanol form or reconverted to synthetic natural gas (SNG).

If conversion were used, the SNG plant would probably be about the same size as a 200-acre LNG plant and would have 19 parallel SNG units each capable of producing 130 MMcfd. The feedstock methanol would be preheated and passed over a catalyst, yielding a mixture of methane, carbon monoxide, carbon dioxide, and hydrogen. After the gas is cooled, the carbon dioxide would be removed in an absorption unit and the gas would be dried. Total plant production would be 2,445 MMcfd of 970 Btu/cf synthetic natural gas or 2,372 BBtud with an energy consumption of 237 BBtud. Besides conversion to synthetic natural gas, other optional uses of the methanol feedstock would be direct firing as a fuel or use in the manufacture of petrochemical products. The SNG would then be distributed by conventional gas pipeline.

The methanol pipeline system would require about the same number of shutoff valves, communications stations, airstrips, helicopter pads, and borrow pits as the natural gas pipeline system.

The problems of transporting both crude oil and natural gas from the Alaskan North Slope to markets in the conterminous United States or other markets in temperate climates have caused controversy ever since the discovery of the Prudhoe Bay field by Atlantic-Richfield in 1968. The TAPS project appears to have solved the crude oil problem but the natural gas transportation system is still under study. Two routes being seriously considered are the Alaska Natural Gas Transportation System with pipelines across Alaska and Canada or an all-Alaska pipeline coupled with an LNG plant and tanker fleet to carry the natural gas as LNG to the conterminous United States.

According to Hooker and Marsden (1975), the FEA is sufficiently concerned about possible delays associated with getting approval for either one of these projects that it has funded a project at the Institute for Energy Analysis at Oak Ridge, Tennessee, to evaluate an alternative method of transporting both the crude oil and natural gas in the TAPS Trans-Alaska pipeline, by examining the potential benefits of conversion of the natural gas to methanol at Prudhoe Bay and transporting the methanol by batching it with the crude oil or by emulsifying the methanol with the crude oil at the proposed TAPS operating conditions (Institute for Energy Analysis, 1974). Serious handling problems at Valdez would result for either system. The proposed operating temperature of the TAPS pipeline is 135-145°F while the boiling point of methanol is 148°F, so that either method of transporting the methanol would have serious boil-off problems.

Hooker and Marsden (1975) have examined a method for transporting both the crude oil and the natural gas in a single carrier, by a system referred to as a cold crude oil-in-methanol dispersion pipeline. Crude oil and natural gas would be produced and treated in standard oilfield separators, with natural gas then directed to methanol plants for chemical conversion by a well-known synthesis process. Methanol and crude oil next would enter dispersion preparation equipment; after the addition of a stabilizing agent to the methanol, the crude oil would be dispersed in the methanol. This crude oil-in-methanol or O/M dispersion would be cooled to temperatures below 0°C and then could be pumped through an entirely buried pipeline with some re-cooling required at pumping stations along the line. The O/M dispersion product could be loaded directly into ordinary tankers at pipeline terminals and after transport could be sent to refineries for separation by standard distillation techniques into its two major components. If ice-breaking tankers or nuclear submarines become available for methanol transportation from the North Slope, the pipeline stage could be eliminated except for lines required to load the tankers or submarines at their offshore terminals (U.S. Dept. Commerce, Maritime Administration, 1975).

Feasibility

Methanol production technology is well established in the manufacture of chemical grade methanol and plant capabilities have been steadily increased from 300 to 2,500 tons per day. Although a 5,000-ton-plant has not been constructed nor have any plants been constructed in Arctic areas as yet, such construction is considered well within the technical confidence level. The same would be true for conventional pipelines.

No SNG plants to handle methanol feedstock have been used to date commercially but a number of plants use similar processes to manufacture SNG from naphtha. A methanol feedstock would eliminate use of the steam-producing equipment needed in naphtha conversion and also the need for facilities required to remove and dispose of pollutants present in some naphtha. Such an SNG plant would give good continuity of service and have a flexible production capacity because of its multiple strings and the provision for upstream storage.

According to the Canadian Arctic proposal (CAGPL, 1974), the total common destination capital cost would be almost 1.5 times that of the Alaska Natural Gas Transportation System and the total operating cost, 3 times greater. Another drawback of the method is its low overall efficiency to a common destination, which is only 48.2 percent with a loss of 2,546 BBtud (Billion British thermal units per day) in contrast to the Alaska Natural Gas Transportation System, which has 90 percent efficiency and only a 489 BBtud loss.

The economic feasibility part of the Hooker-Marsden (1975) O/M dispersion study was based on comparison with the present TAPS pipeline design, using the same pipeline diameter of 48 inches, same length 789 miles, same number of pumping stations, and other components. Because the O/M dispersion pipeline can be completely buried rather than being built on very expensive supports for over half its length, there would be a major cost saving here, for about 60 percent of the TAPS cost is for pipe and its installation and cost of the above-ground pipe portion is three times that for buried pipe. Methanol plants could be built on concrete barges, towed to Prudhoe Bay, beached, and operated on the barges as construction pads. They would be a major cost item. Mixing equipment would be an important but minor cost item. Refrigeration units would be a major cost item. Savings of major but unknown amounts would be achieved by eliminating the need for costly gas injection equipment and CO_2 removal equipment. The total pumping power required (409 Mhp) would be similar to that required for the 2.0 MMbpd of crude oil in TAPS (396 Mhp).

The physical parameters of an O/M dispersion-modified TAPS pipeline system based on 70 percent oil-30 percent methanol dispersion flowing at a total liquid rate of 2.00 MMbpd and at 25°F (-4°C) would be oil flow rate, 1.4 MMbpd; methanol flow rate, 0.6 MMbpd; total liquid flow rate, 2.9 MMbpd; effective natural gas flow rate, 2.7 Bbpd; and chemical dispersing agent, 70 tons/day. The natural gas flow rate of 2.7 Bcfd would be necessary to produce 600,000 bpd of methanol. Of this about 40 percent (1.1 Bcfd) would be solution gas and the remainder must be obtained elsewhere. The trans-Alaska gas proposal calls for 3.5 Bcfd, so sufficient gas would be available beyond that produced as solution gas. To date, only two dispersing agents have worked satisfactorily. One requires a minimum concentration of 0.1 lb/bbl oil and the other, 0.4 lb/bbl oil. The figure cited above is based on 0.1 lb/bbl oil.

Thirty-five methanol plants, each having a capacity of 2500 tons/day, are estimated to cost $50 million each, plus 30 percent for offsites. A trend toward larger plants could lead to economies of scales not included here. Refrigeration requirements would be similar to those for the all-Alaska pipeline-LNG tanker-regasification system and so these costs were based on theirs. Use of surplus heat from the methanol synthesis plants in absorption type refrigeration units for the initial cooling could reduce this cost significantly. Savings on these two major items, plus those on the gas reinjection plants mentioned above, might well change this cost significantly. These savings might change this deficit to a total saving because of the very high cost of construction of the above-ground pipeline.

The increase in the investment required for a modified TAPS line carrying a 70 percent oil dispersion in methanol would be burial of the pipeline (a savings), $2,560 million; methanol plants, $2,275 million; refrigeration units (89,100 hp), $458 million; and mixers, $2.7 million; or a total of $176 million.

Comparison of construction costs for the three proposed transportation systems for oil plus gas shows that, in millions of dollars, the costs would be TAPS plus trans-Alaska gas system, 12.4; TAPS plus Alaska Natural Gas Transportation System, 16.4; and O/M dispersion system, 6.6. The saving would be achieved through the construction of a single pipeline for both components rather than two separate lines, although the figure for the O/M line is believed to be on the conservative side.

In considering the operating expenses for the three systems, for the O/M system, a 12 percent return on investment, 20-year project life, and a 48 percent federal income tax rate were assumed along with straight line depreciation. Additional operation expenses of a modified TAPS line carrying 2.0 MMbpd of a 70 percent O/M Dispersion (in dollars per MMBtu) would be methanol plant, $1.004; dispersant, $0.103; refrigeration units, $0.093; mixers, $0.003; and pumping, $0.057; or a total of $1.26. Most items could probably be reduced in cost. Information from ICI indicates an energy efficiency of 61 percent for methanol plants but a more recent announcement by Lurgi shows 69 percent can be achieved, a significant improvement. Laboratory work might well lead to less expensive chemical dispersing agents, perhaps even one that could be manufactured on site. Absorption-type refrigeration units using surplus heat from methanol manufacture could reduce this cost below that for the evaporation type units. If O/M dispersions could be burned in turbines, then pumping fuel could simply be withdrawn from the line itself.

The estimated or published operating expenses for the two gas systems and the incremental operating expense for the O/M Dispersion system (in dollars per MMBtu) would be Alaska Natural Gas Transportation System, $1.00; trans-Alaska natural gas system, $1.15; and O/M Dispersion system, $1.26.

Reliable costs on the operating expenses for the TAPS line are not available for comparison. These estimates have been made by different groups and at different times.

Numerical comparison of the overall energy efficiency of these three systems indicates that each system will deliver only a part of the energy put into it with the remainder used for pumping and refrigeration and, in the one case, chemical conversion of the natural gas to methanol. The energy efficiencies of the three systems (in percent) would be Alaska Natural Gas Transportation System, 90.8; trans-Alaska natural gas system, 83.1; and O/M Dispersion system, 58.7. The trans-Alaska natural gas system loses energy through its LNG component. Improved efficiency of natural gas conversion to methanol along with use of surplus heat for absorption refrigeration could both improve the energy efficiency of the O/M system.

Besides the energy cost of operation, consideration must also be given to the energy cost of installation. If it is assumed to be proportional to the construction costs, then a significant saving for the O/M dispersion system over the other two is apparent.

One must look beyond the energy costs of transportation to the end uses of the material transported. While the O/M system considered here would carry 1.4 MMbpd crude oil, additional pumping capacity could increase this to about 1.6 MMbpd for a 48-inch pipeline and still be within safe operating conditions. There appears to be some doubt as to whether the west coast of the United States could absorb the full 2.0 MMbpd now or in the near future, so this may not be a serious limitation.

There would be a ready market for the Arctic natural gas from either of the two proposed gas transportation systems at significantly higher prices than current domestic costs but probably lower than those for imported Canadian gas. No estimate is possible of likely gas prices prevailing by the time either system might be completed.

Methanol has many uses as a well-known petrochemical feedstock, a solvent, or a fuel, alone or mixed with gasoline, for internal combustion engines (Faltermeyer, 1975; Reed and Lerner, 1973; and Wigg, 1974). Less-known uses might, with proper development, provide a methanol market for applications in turbogenerators, peak load shaving for limited periods, fuel cells for running motors, and production of single-cell protein as a nutrient to help solve the world's food shortage (Hooker and Marsden, 1975). While these uses might make major contributions to other energy and food problems, they would not solve the dilemma of natural gas distribution companies who want and need gas for their customers. If methanol were produced from Arctic gas, only incentives for further drilling in the conterminous United States, namely, higher field prices, could provide this gas supply. Still, paying high transportation costs for remote Arctic gas would add unnecessarily to the country's energy bills.

Hooker and Marsden (1975) suggest other applications for the O/M method, in somewhat modified form, elsewhere in the Arctic, for gas in the Mackenzie Delta and the Canadian Arctic islands and in Arctic areas of the U.S.S.R. where oil and gas are produced. Conversion of Arctic gas to methanol also would provide the gas-producing areas with a locally produced vehicle fuel besides that put into pipelines. They also consider the O/M system far superior to the other two combined oil and gas transportation systems from the capital investment standpoint and from probably comparable operating costs but admit it is somewhat inferior from the efficiency standpoint.

One factor which should not be overlooked is the stipulations already in force in the agreements and grants of right-of-way made between the TAPS consortium and the governments of the United States and the State of Alaska. These state that nothing except oil may be transported through the TAPS' pipeline without the express prior written permission of the Secretary of the Interior for the United States and the Commissioner of the Department of Natural Resources for the State of Alaska. So any attempt to transport methanol through the TAPS line on either a long-term basis or until ice-breaking tankers and/or nuclear cargo submarines could carry the methanol without use of the TAPS line, would first require the consent of the consortium. Then if this suggestion were agreeable, the consortium would have to submit new applications for permission to carry anything other than oil in the TAPS line to both the U.S. Department of the Interior and the Alaska Department of Natural Resources. If new applications were submitted prior to the start of oil flow through the TAPS line in 1977, the start of oil transportation would probably be delayed until a decision was made on the new proposal. If flow of oil had already started before the new applications were submitted and a favorable decision were received, the full capacity of oil flow through the pipeline might be reached before the methanol facilities could be made ready and thus the pipeline's extra carrying capacity no longer would be available for transporting methanol. In view of the current need in the United States of additional crude oil, any proposal that would delay the 1977 oil flow would not likely be welcomed by the consortium members, the Congress of the United States, the energy agencies of the Federal and State governments affected by such a delay, and particularly by the general public. Also, use of the TAPS line for moving methanol produced from natural gas would not be economically feasible because extensive additional facilities would be needed at both ends of the pipeline, even though those at the south end would actually be used only part time for a relatively short period.

As for the natural gas which would be used to make the methanol, suggestions for its conversion from gas to methanol would defeat the express purpose of the trans-Alaska and the Alaska Natural Gas Transportation System proposals, which were made to insure delivery of badly needed natural gas in its gaseous state to the United States and not to move some other form of energy, which would be useful but not readily substitutable for the present uses of natural gas, especially, in private homes.

Environmental Impact

The methanol pipeline system at present appears to be economically unfeasible although technically viable when compared with the Alaska Natural Gas Transportation System. There is a high energy loss in conversion to methanol. Because of these two factors, it is unrealistic to assume that this approach will be pursued. Accordingly no detailed study of environmental impact is presented here.

The environmental impact of the methanol pipeline, which would follow the Prime route of the Alaska Natural Gas Transportation System, would be similar in many of its components and their environmental effects, which have been described earlier in this report in the Canada volume, Section 3 of the environmental impact and mitigating measures of the Canadian section of the Alaska Natural Gas Transportation System. Only additional differences are included here.

The presence of a methanol plant at Prudhoe Bay, Alaska and at Mackenzie Delta, Canada in permanent permafrost areas (Péwé, 1975) would probably mean that 100 to 150 acres of land would be required for each plant. Each methanol plant would require large amounts of fresh water for use in the synthesis process of changing gas to methanol, as well as additional cooling water from the Beaufort Sea which would be returned to the sea at a higher temperature than the seawater and might cause some of the environmental problems indicated for warm water effluents under the dense-phase pipeline discussion. Because the North Slope fresh water is frozen most of the year, the processing water probably would also have to be taken from the Beaufort Sea and then subjected to desalinization before it could be used in the methanol plant. Desalinization facilities could add considerably to the plant cost. The Maritime Administration report (1975, already cited earlier) suggests that, after the submarines were in operation, their methanol-ballast water could be converted for use in the methanol process and thus eliminate the need for taking water from the North Slope.

A few methanol plants have been constructed on floating barges. Even if this alternative were used, some storage area would be necessary as well as an area on which facilities would be needed to transfer the methanol from the plant to the storage area and then to the pipeline itself. In this North Slope area, it would probably be better to house the plant, storage, and transfer facilities all on one stretch of land. This would disturb the wildlife occupying the area because of the noise and the dust created by the construction machinery and necessitate shifts in habitat and loss of wildlife in the area to be occupied by the plant complex. An estimated permanent staff of about 700 employees would be required to maintain and operate each plant, thus involving additional land for housing and other service facilities to meet their needs. An even larger construction force would require similar facilities but on a temporary basis (CAGPL, 1974).

The low line temperature in the permafrost zone would keep the ground frozen in permafrost areas and prevent degradation of high ice content soils. In the discontinuous and non-permafrost areas, frost bulbs might form and cause some frost heaving in the soils.

The automatic shut-off valve systems used in these pipelines would control the one significant potential but rarely expectable hazard, a possible leak in the methanol pipeline. Methanol in its liquid state could flow over the land, mix with the ground water with which it is mutually soluble, and eventually reach the water courses. In high concentrations, methanol would be harmful to fish. It is also volatile and its highly concentrated vapors could be a health hazard to both humans and wildlife (Reed and Lerner, 1973).

The substantial loss of natural gas inherent in the inefficiency of the methanol pipeline system with the loss of 2546 BBtud of a potential 4918 BBtud would require the substitution of other fuels in the market place to replace this lost gas. Only with very expensive and extensive treatment facilities could these substituted fuels be made as non-polluting as the gas (CAGPL, 1974).

Construction of the regasification plant at the eastern destination in Pennsylvania would involve land requirements similar to those already noted for the methanol plants.

According to Hooker and Marsden (1975), the O/M dispersion system would have ecological advantages over the TAPS pipeline, for O/M dispersions are fluid at temperatures well below 0°C, so the pipeline could be entirely buried, just as the pipelines of the trans-Alaska natural gas system and the Alaska Natural Gas Transportation System would be. Among the advantages of such a cold buried pipeline would be no disturbance of the surrounding permafrost, greater stability in possible seismic disturbances than an above-ground line, less visual impact, no barrier to movement or migration of people or wildlife, and less susceptibility to malicious damage than exposed pipelines.

8-F-3. Railway

Description

Natural gas from producers' gas plants would be liquified at plants that would be located at Prudhoe Bay, Alaska and Mackenzie Delta, Canada. From there it would be transported along the Prime route of the Alaska Natural Gas Transportation System (Figs. 1.1.2.2-1 in the Canada volume and 8-17) as LNG by railroad to Trout River, Northwest Territories, Canada. There it would be unloaded, regasified, and then distributed by conventional natural gas pipelines (CAGPL, 1974).

The liquefaction plants to be built at both Prudhoe Bay and Mackenzie Delta, Canada would each handle 2,250 MMcfd (million cubic feet per day) of gas. Nine pretreatment sections would remove carbon dioxide and water and the remaining gas would be liquified at -260°F (Fahrenheit) in a classical cascade process by nine 250 MMcfd units; then three fractionation sections would separate the heavy ends and provide both makeup for the refrigerant sections and a hot oil belt. Three gas turbines per string would be used to drive the 27 refrigeration compressors and three more turbines would drive the generators that provide electricity for the plant. About 600,000 gallons of sea water per minute would be circulated for cooling with a temperature rise of 14°F. [According to the FPC report (1975a), a proposed LNG plant of about the same size, which might be erected in southern Alaska, is projected to have a once-through water circulation rate of 658,000 gallons per minute and a rise in water temperature of 21°F.] Cooling towers could be substituted for the pass-through system but would add greatly to the cost of the project and would require more land. For efficient operation of this system, storage would accommodate 600,000 barrels or the equivalent of one day's plant output. Storage tanks would be doubled-walled with arctic grade steel on the outside and nickel steel or aluminum on the inside, and insulated with perlite. Tanks would be diked to contain LNG spillage in the event of tank failure. Natural gas consumption for fuel and utilities would be approximately 9 percent of the energy received or 441 BBtud (Billion Btu per day) for each plant complex, which would occupy an area of less than 100 acres. A permanent staff of about 525 would be required to maintain and operate each plant.

The minimum railway facilities needed to handle LNG traffic would consist of a single track standard gauge line between Prudhoe Bay and the Trout River with a spur from the Mackenzie Delta to the Prudhoe Bay-Trout River line. The spur would intercept the main line near Fort McPherson. The railway route would follow the Prime route of the Alaska Natural Gas Transportation System (AAGPC, 1974 and CAGPL, 1974). From Prudhoe Bay the route would go east along the low-lying, lake-dotted Alaska Arctic Coastal plain toward Canada. It would enter the Yukon Territory near Demarcation Point and proceed southeast along the North Slope, skirting the western edge of the Mackenzie Delta to Fort McPherson. The route from the Mackenzie Delta would head south along the east side of the Mackenzie River and intercept the Prudhoe Bay line at Travaillant Lake near Fort McPherson. From the junction of the lines, the railway would continue south essentially paralleling the east bank of the Mackenzie River, across the Anderson Plain, past Fort Good Hope, to the Franklin Mountains. After crossing the mountains through Gibson Pass, the route would enter the Mackenzie Plain just north of Norman Wells and continue to roughly parallel the Mackenzie River, at distances of one to ten miles, to the vicinity of Camsell Bend south of Wrigley. At that point, about 45 miles downstream of Fort Simpson, the railway would cross to the west bank of the Mackenzie River and follow it to Trout River. The line would be 1,240 miles long between Prudhoe Bay and Trout River and 185 miles long from the Mackenzie Delta to the junction near Fort McPherson. Allowing for sidings and yards, a total of 2,065 trackmiles would be necessary. It would require about 375,000,000 cubic yards of fill to construct the railbed with a maximum grade of 0.5 percent compensated for curvature and with a maximum curvature of 2.5 degrees.

To transport the LNG would require about 163 diesel-electric locomotives and about 3,520 tank cars, including spares. Six trains pulling 100 tank cars per train with 170,000 pounds of LNG per tank car would leave Prudhoe Bay. The same number of trains would leave the Mackenzie Delta. However, these trains would have only 95 170,000 pound cars per train. The length of each car would be 102 feet and would have a tare weight of 93,000 pounds. To construct a 102-foot cryogenic tank car with a tare weight of 93,000 pounds would require some additional research in cryogenic tank car construction.

The round trip time from Prudhoe Bay to Trout River would be about 75 hours; from the Mackenzie Delta about 61 hours. The annual revenue freight traffic of LNG from both locations would be 34.96 million tons (CAGPL, 1974).

At Trout River, LNG would be unloaded and stored in cryogenic tanks similar to those at the liquefaction plant sites. Three days' storage, or six 600,000 barrel tanks, would be installed to maintain continuity of service. Each tank would be diked separately for safety. The LNG from the tanks would be pressurized to 1,680 psig (pounds per square inch gauge) and heated and the resulting natural gas would then enter a pipeline system.

Feasibility

Technology for constructing conventional pipelines to transport gas, liquefaction plants, and regasification plants is well developed. No special problems would be anticipated except for any that might arise in connection with the plants, which have never been constructed in Arctic areas before.

The railway presents an entirely different picture, for the size of the project including the requirements for water crossings and construction in permafrost terrain would have a decided influence on proposed construction schedules. If construction of the railway and the pipeline were begun in 1976, indications are that gas could not be delivered by railway before middle or late 1980 while the pipeline would be ready to start gas delivery in 1978 and 1979.

None of the railway equipment required is either available or even designed. Special cryogenic tank cars would have to be designed and tested to make certain that they could perform on a sustained basis under rigorous operating conditions. To assure continuous service of the locomotives, new instruments and protective equipment would be required, some of which has not even been designed or tested.

Bridge construction in connection with the railway may present unique problems in foundation design to cope with permafrost conditions and with support structures to meet ice loads.

The total common destination capital cost of the railway would be almost 1.9 times that of the Alaska Natural Gas Transportation System and the total operating cost, almost five times greater. Based on a daily average energy delivery of 4918 BBtud (Billion British thermal units per day), the overall efficiency of the railway would be 82.2 percent with an approximate energy loss of 884 BBtud as opposed to 90 percent and 489 BBtud for the Alaska Natural Gas Transportation System.

Environmental Impact

About 375,000,000 cubic yards of natural construction material for fill would be required to construct the railway or about 10 times the amount required to construct the Alaska Natural Gas Transportation System. That factor alone is a major consideration. It is unrealistic to assume that this approach will be pursued. Accordingly, no detailed study of environmental impacts is presented here. A few of the problems are highlighted below. The effect of cooling water used in the LNG plant has already been considered under the dense-phase alternative and need not be repeated here.

Devegetation and removal of the organic mat would increase the depth of the active layer and initiate the thawing of permafrost, which makes up most of the area (Péwé, 1975). Excavation of upland gravel sources and alluvial fans would thaw areas underlain by permafrost, would alter local drainage, and would increase erosion locally. Quarry sites would leave scars along the ridgetops and would require erosion control practices to prevent further degradation of the area. Soil flow, soil slump, and landslides could develop if quarry and borrow site slopes are not left in stable or thaw-stable conditions.

Stream flow patterns would be altered by excavation of material from gravel bars and flood plains, and pools would be created in streams, altering the natural habitat. Some siltation of the streams also would occur due to the excavation.

Some borrow pits and quarries would need to remain active because of intermittent requirement of material for maintenance.

If subarctic and arctic construction techniques are not used, major rivers which naturally are already heavily silted could carry an added burden. Clear flowing streams used as habitat and spawning by trout, char, grayling, and salmon could be significantly affected. The noise and activity of construction could temporarily interrupt use of adjacent areas by moose, caribou, nesting waterfowl, and other wildlife.

Over the long term, adverse impacts of railroad operations on wildlife would be certain. There could be interruptions in migratory patterns of caribou and movements of moose and bear.

Environmental impact of railroads includes potential derailments and tank car spillings of the LNG. Derailment could stem from frost heave, differential settling of track bed on thawing permafrost, floods, or snow and land slides.

The railway would also produce noise at irregular intervals.

8-F-4. Monorail System

Description

For the Monorail System, natural gas would be liquified at plants that would be located at Prudhoe Bay, Alaska and Mackenzie Delta, Canada. From there it would be transported by a magnetic levitation type of monorail system along the proposed Prime route of the Alaska Natural Gas Transportation System (Figure 1.1.2.2-1 in the Canada volume) to Trout River. There it would be regasified and distributed by conventional natural gas pipelines.

The system would require LNG plants, storage facilities, and a regasification plant similar in kind and at similar locations to those described for the railway system. The monorail component of the system would consist of approximately 1,400 miles of double track elevated guideway. The guideway would be constructed of prestressed concrete reinforced spans on concrete pillars, and would cross over streams and rivers on conventional bridges. The high-speed unit trains would be levitated above the guideway tracks by magnetic forces and propelled by either linear induction motors or gas turbines (CAGPL, 1974).

Feasibility

The magnetic levitation concept for providing high speed ground transportation is not yet in commercial use (Kolm and Thornton, 1973). Nevertheless, construction of a monorail system is considered to be within the scope of current technology but intensive studies of materials, construction techniques, and construction logistics would be required. Because of the importance of continuity of service in transportation of natural gas, it would be difficult to justify the use of a monorail system without having had many years of proven performance and assurance of its successful operation in an Arctic environment.

Estimates also indicate that the monorail system would use more energy than a conventional railway operating at a much lower speed; its probable overall efficiency would be somewhat lower than 82 percent as compared to 90 percent for the Alaska Natural Gas Transportation System. It would not be possible to complete the necessary studies and construct the monorail system in time to start transporting gas in 1978 and, while no reliable estimates are available, the costs would probably exceed those for building the pipeline.

Environmental Impact

It is unrealistic to assume that this approach will be pursued. Accordingly, no detailed study of the environmental impact is presented here. A few of the problems are highlighted.

Because the environment along the monorail system would be the same as along the Alaska-Canada railway route, many of the impacts to the environment discussed in Railway section would occur if a monorail system were constructed. However, the railroad would require about 375,000,000 cubic yards of natural construction material whereas a monorail system would require about 15,000,000 cubic yards of select concrete aggregate. To prevent thawing of permafrost around the pillars or piers, additional gravel would be necessary for the monorail system. If thawing occurred around the pillars or piers, differential settlement and subsidence would occur beneath the piers. These effects could be sufficiently great to seriously affect the monorail system. The elimination of ground level rolling stock would eliminate collisions between wildlife and the rolling stock. It is not clear whether the monorail would have any effect on bird population. No data are available as to what noise level might be expected with a magnetic levitation system in an arctic region.

8-F-5. Ice-Breaking Tanker

Description

Natural gas would be transported from the producers' gas plants at Prudhoe Bay, Alaska and Mackenzie Delta, Canada by a chilled gaseous-phase pipeline to a deep water port to be developed at Babbage Bight, Yukon Territory, where it would be liquefied and loaded into ice-breaking tankers for shipment to ports on the west and east coasts of the United States, namely, Dana Port, California, and Portland, Maine (Figure 8-17). There it would be unloaded and regasified for distribution through conventional natural gas pipelines. The facilities required would be two sets of pipelines, one to carry gas to Babbage Bight and the other to carry LNG for loading on tankers, a liquefaction plant, an offshore loading terminal, LNG tankers, and unloading terminals and regasification plants (CAGPL, 1974).

A pipeline 48 inches in diameter and nearly 400 miles long, with its related compressor stations and other facilities, would deliver the natural gas to Babbage Bight. This would be a conventional pipeline adapted for use in permanent permafrost terrain.

The liquefaction plant would be similar to that described under the railway alternative but on a much larger scale. The liquefaction plant would handle 4,500 MMcfd (million cubic feet per day) of gas and require 18 pretreatment sections to remove carbon dioxide and water. The remaining gas would be liquefied at -260°F in a classical cascade process by eighteen 250-MMcfd units and then six fractionation sections would separate the heavy ends and provide both make-up for the refrigerant sections and a hot oil belt. Gas turbines would be used to drive refrigeration compressors and generators that provide plant electricity. About 1.2 million gallons of sea water per minute would be circulated through the plant for cooling purposes with a temperature rise of 14°F. Cooling towers could be substituted for the pass-through system but would add greatly to the project cost and require more land. Storage would accommodate 3,600,000 barrels or the equivalent of three days of plant output or three tanker loads of LNG. Natural gas consumption for fuel and utilities would be approximately 9 percent of the energy received or 442 BBtud. The plant complex would occupy an area of about 200 acres.

The loading terminal at Babbage Bight would be constructed about 3.5 miles offshore in contrast to the use of locations 25 or 15 miles offshore required, respectively, at Prudhoe Bay and Mackenzie Delta because of the shallower water there. The pipelines connecting the shore-based storage with the offshore terminal would consist of four 28-inch diameter insulated LNG pipelines and four 26-inch insulated vapor return pipelines. All pipelines would be buried in the seabed. Equipment at the loading terminal would load two tankers simultaneously.

The LNG tankers with capacities of 200,000 cubic meters or about 1,200,000 barrels would be most economical. Length would be approximately 1060 feet, beam 160 feet, depth 95 feet, and draft 44 feet. An estimated power-plant requirement would be 160,000 horsepower (hp) for an open water service speed of 22 knots. (For 125,000m^3 tankers, hp would be 138,000 and speed, 19 knots.) The routes would end at Portland, Maine on the east coast and Dana Port, California on the west coast. The fleet would require 25 ice-breaking tankers and would deliver about the same amount of LNG to each coastal port throughout the year, except that difficulties on the eastern route resulting from ice conditions during April and May would make total delivery to the west port more desirable then. Tanker power would be supplied by boiloff natural gas from the LNG tanks at a rate of one-fourth of one percent per day supplemented by fuel oil, and would make average energy efficiency of the fleet about 91.1 percent.

Facilities at Portland and Dana Point would include three major components, an unloading terminal, cryogenic storage tanks, and a regasification plant. Both terminals would be able to unload two 200,000 cubic meter tankers simultaneously. Tankers, however, do not carry the full quoted capacity, so the tanks are normally filled only to 98 percent and a residue of 3 percent is left at the point of discharge. The LNG would be pumped from the tankers into cryogenic storage tanks. Capacity at Portland would be 3 million barrels. The design throughput would be 2040 MMcfd and gas would be supplied ten months of the year. At Dana Point, storage capacity would be 4.8 million barrels and design throughput, 4,090 MMcfd. The plant would operate here at full capacity in April and May and only at half capacity the rest of the year unless some supplemental sources of LNG were secured during this period. The regasification plants would pressurize the gas up to 1,680 psig (pounds per square inch gauge) and heat it with about 18 onstream gas-fired vaporizers. The resulting gas would then be ready for transportation by a conventional gas pipeline. Methanol could be substituted for LNG by preparing the gas according to procedures already described under the methanol pipeline alternative and then shipping it like the LNG.

Feasibility

Technology for constructing the conventional pipelines to transport gas to Babbage Bight and insulated pipelines to carry the LNG to the loading terminal and the liquefaction plant is well developed.

Major problems in constructing the loading terminal would be development of a terminal structure capable of withstanding sea-ice forces and development of a reliable system for laying offshore LNG pipelines to prevent damage from drifting ice because the main problems of ice scour and impact are not fully understood.

Using either Prudhoe Bay or Mackenzie Delta as shipping ports would increase the costs and hazards of shipping because it would require the use of longer undersea pipelines and a loading terminal at a greater distance offshore. This would also apply to other ports of departure or other tanker routes.

While LNG marine transportation is relatively new, the first largescale commercial use being started in 1964, it has developed rapidly since then and plans for the design of 200,000 m³ tankers have been prepared (El Paso Alaska Co., 1974; Mostert, 1974; Wilson, R., 1973; and Fay and Mackenzie, 1974). There is at least one known design for an ice-breaking supertanker to carry oil from the Arctic area, but none of these has actually been built. The largest ice-breaking vessel which has operated in the Arctic thus far is the 114,668 DWT MANHATTAN which made two voyages in 1969 and 1970. Those voyages should provide sufficient data on forces and accelerations to permit the design of a hull configuration and a cryogenic tank system which would withstand the forces and accelerations of ice breaking. The necessary characteristics of an adequate hull configuration would be an ice-breaking bow of the standard type (experiments with "novel" ice-breaking bows have given poor results), addition of a high-tensile steel ice-belt to protect areas of shell plating exposed to ice damage (the ice-belt could require up to 2.5 inches of A537B steel extending from lower turn of the bilge to about ten feet above load waterline), and incorporation of additional hull framing and stiffening members. The major problem of converting a standard hull into an ice-breaking hull had been posed by the need to construct a double hull, but now that standard LNG tankers are being built with double hulls, all the above changes could be made without major changes in the ship's dimensions.

The design of a fossil-fuel power plant capable of year-round operation in the Arctic is certainly possible. In the near future, nuclear power may become a feasible and economically superior alternative. At the present, however, there are no commercial maritime reactors in use in this country, and the time of their availability must be considered uncertain. The first tankers probably could be delivered before the natural gas pipeline could be completed; however, construction of a fleet of 25 ships would undoubtedly extend beyond the anticipated initial gas delivery dates.

There would be no problem with unloading tankers at eastern and western ports or storing and regasifying LNG, for the technology of these processes is well developed.

The questions of efficiency and cost of the entire ice-breaking tanker system deserve serious consideration. According to the Canadian Arctic proposal (CAGPL, 1974), the overall efficiency to a common destination of the tanker system would be 80.6 percent and entail an approximate energy loss of 1,011 BBtud (billion British thermal units per day), including the additive liquid fuel, as opposed to 90 percent efficiency and loss of only 489 BBtud in the Alaska Natural Gas Transportation System. The total common destination capital cost for the tankers would be about 1.5 times that of the natural gas pipeline and the total operating cost, almost six times greater.

As an alternative to shipping the natural gas and LNG by ice-breaking tanker, the North Slope gas could be converted to methanol using the procedures described under the methanol pipeline alternative and then be shipped out the same way as the LNG. Shipping methanol would have some advantages over LNG shipments for methanol does not require either the maintenance of such low temperatures or the use of cryogenic tanks. Slightly modified oil tankers could be used.

Environmental Impact

The problems of designing and putting into operation an ice-breaking tanker system to carry either LNG or methanol within the time frame required by the availability of the North Slope gas for shipment appears to make this system economically unfeasible at present and therefore all of its potential environmental effects are not considered in detail.

The environmental impact of the ice-breaking tanker system would include some features of the Alaska Natural Gas Transportation System and some of the same environmental effects, which have been described earlier in this report in the Canada volume, Section 3 on the environmental impact and mitigating measures of the Canadian section of the Alaska Natural Gas Transportation System pipeline route. Only these few similarities will be noted here along with other environmental impact factors. Because the Yukon North Slope has no oil or gas facilities now, there would be substantial environmental and socio-economic impacts.

A pipeline 48 inches in diameter and nearly 400 miles long with its related compressor stations and other facilities like those of the Alaska Natural Gas Transportation System would be required to deliver the gas to Babbage Bight for liquefaction or conversion to methanol. The same environmental effects as those of the Alaska Natural Gas Transportation System would be present but on a smaller scale.

The presence of either an LNG liquefaction plant or a methanol conversion plant at Babbage Bight would mean that 100 to 200 acres of land would be required for the plant. This would disturb the wildlife occupying the area because of the noise and dust created by the construction machinery and necessitate shifts in habitat away from the area to be occupied by the plant complex. An estimated permanent labor force of over 500 would be required to operate and maintain the LNG plant, thus involving additional land for housing and other service facilities to meet their needs. An even larger construction force of 1600 to 1700 would require similar facilities but on a temporary basis.

The effects on the climate and the marine environment of a 14°F rise in temperature of sea water returned to the Beaufort Sea after use in the plant cooling system have already been described in detail under the Dense-Phase pipeline alternative and the description need not be repeated here.

This is also an area with a high seasonal concentration of wildlife, particularly staging snowgeese and caribou. Some waterfowl could also be affected because of the plant's location on the coast. The pipelines leading to the loading terminal are expected to be buried in the seabed and thus should have little or no effect on the environment, except if unexpected leaks should occur and pollute the water of the southern Beaufort Sea.

The loading terminal would be built about 3.5 miles offshore to provide sufficient water depth and to accommodate the frequent tanker traffic. It would occupy a marine area which supports the feeding, migration, and calving activities of marine mammals, such as belugas, bowheads, bearded seals, ring seals, and walrus, and other types, and also of polar bears, even though the frequency of occurrence of such animals is quite variable. The combined effects on wildlife of the LNG or methanol plant complex, the frequent presence of tankers, and the offshore loading terminal could be substantial but the total effects cannot be determined readily. By careful design and operation some of the effects could be kept small; offshore platforms in the Gulf of Mexico, for example, provide shelter for some sea life.

The coastal ports to which tankers would deliver the LNG or methanol require docking and related facilities and adequate LNG or methanol storage tanks, similar to those at Babbage Bight, as well as a regasification plant for LNG or, if methanol were converted back to gas, a conversion plant. All these factors could have substantial environmental and socio-economic effects on the occupied areas.

If methanol were to be substituted for LNG in this alternative, then all the environmental impacts already described under the methanol pipeline alternative would also apply here.

8-F-6. Submarines

Description

Natural gas would be transported from the producers' gas plants at Prudhoe Bay, Alaska and Mackenzie Delta, Canada by a chilled gaseous-phase pipeline to a deep water port to be developed at Babbage Bight, Yukon Territory, where it would be liquified and loaded into submarines for shipment to Portland, Maine (Figure 8-17). No use of a west coast port was planned because the water in the Bering Straits is too shallow to accommodate submarines. At Portland, the gas would be unloaded and regasified for distribution by conventional gas pipelines. The facilities required would be two sets of pipelines, one to carry the gas to Babbage Bight and the other to carry the LNG for loading on the submarines, one liquefaction plant, an offshore loading terminal with underwater loading facilities, LNG submarines, and an unloading terminal and regasification plant (CAGPL, 1974).

The pipeline to Babbage Bight and the LNG plant would be the same as those already described under the ice-breaking tanker alternative and the description need not be repeated here.

According to the Canadian Arctic proposal (CAGPL, 1974), the underwater loading offshore terminal at Babbage Bight must be located in 300 feet of water because of the size of the submarines and the water depth of the sea-ice pressure ridges. It would, therefore, be located at least 14 miles offshore and be capable of loading two LNG submarines simultaneously. Construction of such an underwater terminal at Prudhoe Bay or Mackenzie Delta was not even considered because that would require underwater pipelines even longer than the 25- and 15-mile ones required for the ice-breaking tanker. A special system of seabed navigation aids would be needed to enable the submarines to locate, approach, and berth at the terminal.

The fleet of submarines would have to be capable of loading under water and making a submerged round trip between Babbage Bight and Portland, Maine. Approximate dimensions suggested for a cargo submarine are length 1000 feet, beam 170 feet, and depth 90 feet. The energy carrying capacity would be about 100,000 cubic meters of LNG. Installed horsepower (hp) is indicated at 75,000 for an estimated service speed of 16 knots. On the basis of the suggested capacity and speed, the fleet would require 45 submarines.

The facilities at Portland would consist of three major components, an unloading terminal, a cryogenic storage area, and a regasification plant. Because this would be the only coastal terminal used in the submarine system, provision would be made to insure sufficient capacity to off-load, store, and regasify the total LNG plant output of 1,200,000 barrels per day (CAGPL, 1974; Wilson, R., 1973).

An alternative energy form in which natural gas could be carried from the North Slope by submarine would be to convert it to methanol by procedures described under the methanol pipeline alternative. Then shipment would be made by nuclear submarine as proposed, especially in the environmental impact statement, volume 3 of a 7 volume Arctic Submarine Transportation report (U.S. Dept. Commerce, Maritime Administration, 1975). The report suggests that the Prudhoe Bay gas be converted to methanol by the procedures already described. Then, until the submarines for shipping it became available, it would be sent as methanol slugs or batches through the TAPS oil pipeline now being built across Alaska from Prudhoe Bay to Valdez. This would be possible during the earlier years of oil shipment when full pipeline capacity would not be used. By the time the TAPS line could no longer accommodate the methanol as well as the oil, it would be expected that the nuclear cargo submarines would be ready to carry the methanol directly from the Arctic to an eastern U.S. port without using any pipeline except the one from the methanol plant at Prudhoe Bay to the underwater loading terminal. This would be 40 miles offshore in water up to 500 feet deep where there would be no possibility of damage from keels of ice pressure ridges or ice islands overhead. At its destination on the eastern coast of the United States, the submarine would unload its methanol cargo under water and bring it to shore by pipeline, where it could be used for energy purposes in the form of methanol or regasified in a plant for distribution as gas.

Feasibility

For the LNG and methanol proposals, technology for the pipeline and the liquefaction, regasification, and conversion plants is well developed. The underwater terminal in both instances might pose a number of technical problems still to be resolved because no such terminal exists today. The LNG project would require underwater pipelines five times longer than any present surface line and those used for the methanol transport would be even longer. Environment and distance also create problems with regard to pump and refrigeration station needs, insulation, and circulation to prevent the LNG from vaporizing in situ. All the pipelines and facilities would require special protection against damage from drifting and grounding ice even though it is proposed that the underwater pipelines would be buried beneath the sediments of the Beaufort Sea.

No large-scale cargo submarines of a nuclear or non-nuclear type have ever been built yet for commercial use, although suggestions for the models to be used for methanol transportation are described in the Maritime Administration report cited above. It would still take some years, probably not until 1984, before the first of these submarines could be made available for use in transporting either LNG or methanol, possibly extending beyond the time frame proposed for the Alaska Natural Gas Transportation System. The methanol-carrying submarine advocates propose the use of the TAPS pipeline for carrying methanol batches or slugs until the submarines become available to transport the methanol directly from Prudhoe Bay to the east coast port in the United States. A review has already been presented in full, under the methanol pipeline alternative, of the problems which might arise from such a proposal because of the stipulations in the agreements and grants of right-of-way made by the TAPS consortium with the governments of both the United States and the State of Alaska that nothing but oil may be carried in the TAPS pipeline without permission from the proper authorities in both jurisdictions, so the description need not be repeated here. It would mean a time-consuming period during which the submarine-transport companies would have to get the consent of the TAPS consortium to ship methanol with the oil. Then, were the suggestion agreeable, the consortium would have to file new applications for permission to carry anything other than oil alone in the TAPS pipeline. The resulting delays until a favorable or unfavorable decision was reached by both the U.S. and Alaska government agencies might add to the present United States energy crisis instead of relieving it.

Another difficulty is the absence of adequate recent hydrographic charts of the LNG submarine route. A three to four year program of detailed hydrographic surveying would have to be carried out to chart the navigational hazards of all the potential routes (U.S. Dept. Interior, 1972). The same would be true of the polar route through international waters proposed for the nuclear submarines carrying methanol. The Maritime Administration report (U.S. Dept. Commerce, Maritime Administration, 1975) suggests that the U.S. government aid in this portion of the submarine transportation proposal by using U.S. Navy submarines to study the under-ice problems along their proposed routes, but the Navy's manpower requirements might not be up to implementing such a project even if it might be helpful in the long run for the Navy's own nuclear submarine projects.

Hazards and costs of shipping either LNG or methanol would rise whenever the length of the undersea pipelines and the distance offshore of the underwater terminal were increased as would be the case with the use of terminals at either Prudhoe Bay or Mackenzie Delta.

Special techniques and navigational aids would have to be developed to guide the submarines to the Arctic loading terminal under ice-filled waters.

From the human standpoint, failsafe methods would be imperative to insure the prompt rescue of submarine crews should mechanical or other unexpected difficulties develop causing the vessel to stop beneath a thick layer of surface ice.

Sufficient information is not available nor is the system sufficiently planned and developed for an accurate determination of the estimated energy efficiency of transporting LNG or methanol by submarine. If it should prove to be comparable to that of the ice-breaking tanker, with which it has many components in common, the efficiency might reach about 80.6 percent. For the same reasons, reliable estimates of the capital and operating costs cannot be made with any degree of accuracy.

One of the main advantages of shipping natural gas in the form of methanol rather than as LNG would be that the methanol would not require either the maintenance of such low temperatures or the use of cryogenic tanks because the same type tanks used for carrying oil could also be used for methanol transport. The lower efficiency of methanol as an energy source, already pointed out in detail under the methanol pipeline alternative and not repeated here, as compared to natural gas (i.e., about 48.2 percent for methanol and certainly not above 60 percent under the best present conditions versus 90 percent for the natural gas) is a major factor which detracts from the desirability of using a methanol shipping system. The fact that the end product is a useful energy source but not readily substitutable in the present major uses of natural gas, especially the 21 percent of the gas used in private homes, also makes the system less feasible.

The methanol submarine transport system would use nuclear rather than fossil-fueled submarines to carry methanol and thus would retain the concept of use of the sea instead of land areas, with the result of eliminating almost entirely the environmental impacts on land areas caused by building the Alaska Natural Gas Transportation System and perhaps avoiding most of the problems of travel through sea ice experienced by ice-breaking tankers. The present slow development of nuclear power plants to fuel merchant vessels and commercial submarines and the long periods required to process licensing applications would both suggest that use of nuclear submarines does not appear to be a promising possibility anytime in the near future, even though experience in the successful operation of military nuclear submarines, particularly the N.S. Savannah, suggests that environmental impact of such use of nuclear power would be low. Although nuclear risks involved in the methanol submarine transport system would be expected to be low or zero, some form of nuclear risk indemnification would be an essential part of such a proposal. Because it is unlikely that such nuclear risk insurance would be available from commercial insurance companies, the Maritime Administration report already cited above suggests that this nuclear risk be underwritten by the United States government in addition to the regulatory rules and licensing which already involve government action. Environmental monitoring baseline studies of the Beaufort Sea, required prior to BLM offshore leasing, would probably also be carried out by the U.S. government through NOAA and the National Science Foundation's Office of Polar Programs. Government willingness to undertake such additional costly projects might well be deemed questionable or doubtful in a period of economic as well as energy crisis with stress being laid on the need to reduce government expenditures.

Environmental Impact

The environmental impacts of the LNG or methanol submarine system would include some features of the Alaska Natural Gas Transportation System, which has been described earlier in this report in the Canada volume, Section 3 on the environmental impact and mitigating measures of the Canadian section of the Alaska Natural Gas Transportation System. Only these few similarities will be included here along with other environmental impact factors, which will not all be described in detail. Because the Yukon North Slope area has no oil or gas facilities now, there would be substantial environmental and socio-economic impacts. In this submarine transport system, problems of building the cargo submarines and pipelines and terminals, getting permission to fuel the submarines by nuclear power, and starting shipping operations within a reasonable period within the time frame required by the availability of the North Slope gas for shipment do not appear to make this system feasible at the present time although it might be a practical method of shipping Arctic gas and oil sometime in the future.

The environmental impacts of the LNG method using a pipeline, an LNG plant, the problems of thermal water discharge into the Beaufort Sea, and the underwater pipelines are similar to those already described fully under the ice-breaking tanker alternative, so the description need not be repeated.

This is also an area with a high seasonal concentration of wildlife, particularly staging snowgeese and caribou. Some waterfowl could also be affected by the plant's location on the coast.

Construction and operation of the loading terminal would differ from that of the tanker system because the loading of the LNG or methanol would take place under water. These underwater activities might well create danger of accident or spill even though the proposed underwater pipelines would be buried under the Beaufort Sea sediments. Absence of actual operating data for large commercial submarine cargo carriers because none has yet been built and the limited use of military submarines in Arctic waters both make the evaluation of environmental impacts of underwater operation in ice-covered waters very difficult. The risk of accidents might prove to be high during the development period. Thus all these factors present problems in any attempt to determine the exact total effects of the plant, the underwater pipelines, the underwater terminal, and the submarines themselves on the land and marine wildlife of the Yukon North Slope area.

Both the LNG and methanol submarine systems would require underwater travel to ports on the east coast of the conterminous United States, underwater unloading facilities, storage tanks, and a regasification plant in the LNG system or if the methanol were converted back to gas, all of which would unquestionably have considerable environmental effects on the occupied areas, similar to those at Babbage Bight or Prudhoe Bay.

8-F-7. Airplane

Description

Natural gas from the producers' gas plants at Prudhoe Bay, Alaska and Mackenzie Delta, Canada would be liquified in liquefaction plants, stored, and then transported by airplanes, in pods attached to the wings, either to Trout River where it would be regasified for transport by pipeline via Monchy and Kingsgate to western and eastern common destinations; or directly from Prudhoe Bay to San Francisco for distribution to western markets and from Mackenzie Delta to Winnipeg for distribution to the eastern markets. At each delivery point a regasification plant would have to be built to prepare the LNG for pipeline shipment to the markets (Fig. 8-17). The facilities required for the LNG airplane system would be two liquefaction plants with storage facilities, the proposed Boeing RC-1 airplanes themselves, either one or two regasification plants, and pipelines for gas distribution to western and eastern markets (CAGPL, 1974; Wilson, R., 1973).

The liquefaction plants to be built at both Prudhoe Bay and Mackenzie Delta, Canada would be the same as those described under the Railway alternative and the description need not be repeated here.

The proposed Boeing RC-1 airplane would be a 12-engine plane fueled by LNG and capable of a speed of 400 knots with a gross weight more than four times that of a Boeing 747 and three times the size of the current largest airplane, the Lockheed C-5A. The plane would be 338 feet long, 80 feet high, and 68 feet wide with a wingspan of 478 feet. The LNG cargo would be carried in wing-mounted detachable pre-loaded pods, 26 feet in diameter and made up of four identical containers. Each pod would carry about 500,000 pounds of payload, with a total payload per plane of 2 million pounds. Maximum gross weight of the loaded plane would be 3,500,000 pounds and of an empty plane, 955,000 pounds.

Two-men crews would be required in the air. In the so-called Short Range route ending at Trout River, a total of 23 RC-1 airplanes would be needed, with 13 flying the Prudhoe Bay leg and 9 the Mackenzie Delta leg, with one plane to spare for attrition. On the Prudhoe Bay leg, 92 two-men crews would be needed and on the Mackenzie Delta leg, 63 crews. In the Long Range route, a total of 42 RC-1 airplanes would be needed, with 23 planes and 186 two-men crews flying the Prudhoe Bay to San Francisco airlift and 18 planes with 136 two-men crews flying the Mackenzie Delta to Winnipeg airlift, with one plane for attrition. Runway systems, control and communications systems, maintenance systems, and administrative and operating facilities would be needed at the northern and southern bases under both the Short and Long Range routes. The total base personnel, including staff for loading and unloading operations, maintenance, base operations, supplies and services, and supervisory functions has been estimated at about 200 each for Prudhoe Bay and Mackenzie Delta. Where Trout River is the southern terminal, about 2,000 employees would be needed, the majority of whom would be engaged in over-haul and maintenance of airplanes. Where San Francisco is the western terminal, about 1800 employees would be needed, and at Winnipeg, about 1500, all performing similar functions to those at Trout River.

The regasification plants would be of the same type at all 3 proposed terminals. The Trout River plant would need 17 onstream gas-fired vaporizers capable of vaporizing 1.11 million bpd (barrels per day) of LNG, thus producing about 3.63 Bcfd (billion cubic feet per day) of 1110 Btu (British thermal units) gas (4,026 BBtud, billion British thermal units per day) at a pressure of 1680 psig (pounds per inch gauge) for introduction into the pipeline. Only one day's combined-production storage of LNG (about 2,400,000 barrels) would be provided. At San Francisco, the plant would use 8 onstream gas-fired vaporizers capable of vaporizing 0.5 million bpd of LNG to produce 1.58 Bcfd of 1.153 Btu gas (1,764 BBtud). One day's delivered LNG storage capacity would be provided. At Winnipeg, the plant would use 8 onstream gas-fired vaporizers capable of vaporizing 0.5 million bpd of LNG to produce 1.66 Bcfd of 1,066 Btu gas (1,774 BBtud). One day's delivered LNG storage capacity would be provided. Conventional pipelines would transport the resulting natural gas to its eastern and western destination.

Feasibility

Although technology for liquefaction and regasification plants and pipelines is well developed, the proposed Boeing RC-1 airplane and its attendant facilities will create a number of problems in this system.

Technology exists to build an airplane three times the size of the current largest one, the Lockheed C-5A, but it involves a high degree of uncertainty that cannot be resolved without extensive engineering design efforts. The first plane probably could not be delivered before 1980 at the earliest and the system is not judged to be feasible within the time frame of the proposed pipeline.

Because of the many unknown variables, there is no way that the overall efficiency of the airplane system can be estimated, although 78 percent has been suggested. The estimated total common destination capital cost would be almost 1.5 times that of the gas pipeline while the total estimated operating cost would be four times greater.

Environmental Impact

It is unrealistic to assume that this approach will be pursued within the time frame of the proposed pipeline. An assessment of the environmental impact of this system is not possible at the present time, and no analysis of impact has been made.

8-F-8. Helifloat

Description

Natural gas from the producers' gas plants at Prudhoe Bay, Alaska and Mackenzie Delta, Canada would be liquified in liquefaction plants, stored, and then transported by Helifloat, an aircraft combining characteristics of a helicopter, a buoyancy craft, and an airplane, to a southern terminal, as yet unspecified. The Helifloat is not sufficiently developed for payload vs distance tradeoffs to be considered. At the terminal, LNG would be regasified and then transported by conventional pipeline to the eastern and western common destinations. The facilities required for a Helifloat system, which is really an extension of the airplane system, would be liquefaction plants with storage facilities, the novel Helifloats, a regasification plant, and pipelines for gas distribution to eastern and western markets (CAGPL, 1974; Wilson, R., 1973).

The liquefaction plants to be built at both Prudhoe Bay and Mackenzie Delta, Canada would be the same as those described under the Railway alternative, so the description need not be repeated here.

The Helifloat, a novel aircraft proposed by the Arctic Helifloat, Ltd., differs from conventional air transport vehicles by combining the characteristics of a helicopter, a buoyancy craft, and an airplane in a configuration which it is claimed would create a total lift many times that of the various components combined. Its proponents call the operative principle "induction air-foil lift." A fleet of an, as yet, unspecified number of Helifloats would be required, each having the following conceptual specifications: length 1,200 feet; width 800 feet; height 250 feet; gross takeoff weight 7,900,000 pounds; payload 6 million pounds or approximately 37,000 barrels of LNG; and total installed horsepower of approximately 90,000. The Helifloat would cruise at 100 mph (miles per hour) when loaded and at 200 mph when empty and would use an air bag landing system, thus eliminating the need for long runways. However, a single Helifloat would require a leveled area of about 24 acres just for parking. Because of the early stage of development of the Helifloat concept and the lack of designs, it was not considered feasible to develop the physical requirements for either the fleet or the loading and unloading terminals.

The regasification plant would be of the same type as those proposed for the LNG airplane system. Since only one is planned, it probably would have the same specifications as the plant proposed for and described under the airplane system at the Trout River area. Conventional pipelines would transport the resulting natural gas to its eastern and western destinations.

Feasibility

Technology for liquefaction and regasification plants and pipelines is well developed, so that their level of technical confidence can be considered to be high.

As for the Helifloat itself, only scaled-down individual components of the Helifloat have been tested to date, in order to secure the prerequisites to construction and testing a prototype about one-third the size of the vehicle proposed for airlifting LNG. If the plan is carried out, an estimated three-year development period would be needed before this prototype would be ready for flight-testing. If it worked, an additional long period would be required to build, test, and evaluate a full-scale Helifloat. Overall it would probably take nine to ten years to develop the Helifloat or at least five years longer than for the Boeing RC-1 proposed for use in the airplane system. Until a Helifloat has actually been built and flown, only potential operating problems can be considered and would relate, among others, to stability and control, ride characteristics in rough air, allowable forces on the structure as it deflects under control loads, and ability to operate under icing conditions. Helifloat efficiency estimates cannot be determined realistically because of lack of information on the fuel requirements but, according to its proponents, over the same distances the Helifloat would be expected to have a higher efficiency than the airplane. Firm estimates of capital cost and operating cost cannot be made because of lack of data, but it is probable that development cost alone would be far higher than the minimum development cost set by Boeing at one million dollars for the RC-1. This figure takes into consideration the fact that the Boeing 747 manufacturing plant could be used to build the RC-1, whereas there are no Helifloat plants at present and when they are built, they would have to be far larger than the 747 plant.

Environmental Impact

It is unrealistic to assume that this approach will be pursued within the time frame of the proposed pipeline. Insufficient data are available to evaluate the environmental impact of a Helifloat.

8-F-9. Dirigible

Description

Interest in dirigibles for cargo transportation has been rising and the first international conference on dirigibles was held in 1973, so the possibility of using this method for LNG transport warrants mention.

Miles E. Sonstegaard has made extensive studies on the possible transport of LNG by dirigible on the principle that possibly the cheapest way to transport a commercial gas would be to put it in a streamlined bag and float it in the atmosphere. According to his findings, reported in 1970, natural gas could be transported by large dirigible airships from the Alaskan North Slope to the New York-Philadelphia area at a price (based on 1970 figures) competitive with gas pipelined from the Gulf Coast region, namely, about 38 cents per Mcf (thousand cubic feet) of gas delivered. The following discussion is based on his studies (Biederman, 1970).

Natural gas from the producers' gas plants at Prudhoe Bay, Alaska and at Mackenzie Delta, Canada would be liquified in liquefaction plants, stored, and then transported by dirigible, of which the cargo would include unliquified natural gas and also ballast of LNG or liquified methane. The system would involve liquefaction plants with storage facilities, the dirigibles themselves, and, at the southern terminals, regasification plants and compressors for preparation of gas for pipeline transport.

The liquefaction plants at Prudhoe Bay and Mackenzie Delta would probably be similar to those described under the Railway alternative and the description need not be repeated here.

The proposed dirigible system would include an unmanned cargo dirigible 6130 feet long, with a maximum diameter of 1345 feet. Besides the unmanned cargo airship, there would be a manned control blimp and perhaps two drone scout blimps. They would fly a route at 5000 feet above sea level, carrying a cargo of about 3.7 billion cubic feet of natural gas at an air speed of 50 miles per hour. For the capacity described above, the cargo airship would displace 179,200 tons at an altitude and temperature equivalent of 4000 feet and 90°F. Hydrogen is assumed to be the lifting gas and the airship travels with a cargo of natural gas and liquified methane. Presumably the airship would return ballasted with air, which would be dangerous if the storage tanks were purged with nitrogen or another suitable gas each time they are unloaded. The airships would be of the non-rigid type (blimps) with a flexible framework of cables just inboard from the outer envelope.

The outer envelope of the cargo ship would contain an inert gas to shield the cargo gas from danger of leakage in the event that the bag were punctured, because the inert gas under positive pressure would leak rather than the cargo gas. It would also be ballasted by a cargo of liquid methane or LNG. The inner vessel would be divided into two sections, one for the cargo gas and the other for hydrogen to act as the lifting gas for all load other than cargo gas and fuel. The fuel would consist of boil-off gas from the cryogenic cargo and fuel gas.

Temporary storage facilities at both northern and southern terminals would be unusual. Their structure would be paraboloid in shape but would have an effective diameter of 2506 feet if the structure were hemispheric. The inner storage bag would be covered by another to contain a five-foot layer of nitrogen between the inner vessel and the atmosphere. A third bag would surround the two inner bags to protect them from the elements. At the receiving terminal the gas would have to be compressed for transport by pipeline to market.

Cost estimates by Sonstegaard are admittedly rough but permit arriving at a proposed delivery price of 38 cents per Mcf. The total cost of the cargo blimp, the manned controlled blimp, and two remotely controlled scout blimps would be about $65 million, of which the cost of the cargo ship alone would be about $43 million.

An average cruising speed of 30 mph with fuel consumption of 376,000 cf per hour is projected, so that a 10,000-mile trip would require 333 hours travel time and 125 million cf of fuel or a total of 2800 tons. If the airship were in flight 80 percent of the time or 70,000 hours and loaded with 143,000 tons of payload half the time, the airship would produce 15.0 billion ton-miles of freight service per year. If the proposed annual operating cost were to be $15.145 million per year, the cost per ton-mile would be 1.01 mills or, on the basis of 0.70 gravity natural gas, 0.27 cents per Mcf per 100 miles. Thus, for a trip of 3600 miles from Alaska to the New York-Philadelphia area, a charge for transportation of 9.7 cents per Mcf would be incurred.

Cost of the terminal storage facilities at both ends including the cargo storage bag, nitrogen shell bag, outer envelope, and floor would total about $30 million. If these facilities were cycled 50 times a year to a capacity of 3.736 Bcf, the cost of storage would be 3.2 cents at each end or 6.4 cents at both receiving facilities. At the eastern receiving facility, there would also be a cost for compression for pipeline transport amounting to about 4 cents per Mcf. Consideration of all these costs would make the total cost per Mcf about 38 cents.

Feasibility

The technology is available to construct the liquefaction and regasification plants required in this transportation system.

As with the Helifloat system, the sheer size of the components in the system might create a drawback to its inception. Although dirigibles require no runways or related landing facilities, there would undoubtedly be difficulties in mooring an airship over a mile long and containing approximately 70 million therms of energy. The technology required to construct such a dirigible and its associated blimps would take considerable time and study, not to mention the huge monetary investment required, for figures cited above do not include the cost of the liquefaction plants.

Most people at the international conference on airships believe that they are still at least ten years away from a possible use date, or far too late for use when the first North Slope natural gas becomes available for transport. Shell is experimenting with the use of smaller sized blimps to try to transport natural gas from the Middle East in lieu of building LNG plants there and expects to be successful in gas transportation from that type of climatic area. However, the strong winds in Alaska would make any extensive transport of natural gas by dirigible virtually impossible (Bond, 1974; Vaeth, 1974; Kilpatrick, 1975; Smith, 1974).

The airline distance from the North Slope gas fields to New York is about 3,000 miles, indicating a 600 hour round-trip at the proposed cruising speed. To this must be added time for loading and unloading, so that the 50-cycle per year rate proposed would appear to be unrealistic.

Environmental Impact

In view of the fact that designs for this possible mode of transportation are not even on the drawing boards and have no possibility of being developed in time for use in transport of North Slope gas, at this time no analysis of environmental impact is possible on any realistic basis.

8-F-10. Electrical Generation and Transmission

Description

Natural gas from the producers' gas plants at Prudhoe Bay, Alaska and Mackenzie Delta, Canada would be converted by electrical generating plants, fueled by natural gas, to electricity, first to HVAC (high voltage alternating current) as the plant output and then further converted to HVDC (high voltage direct current) for transmission to eastern United States and

Canada by HVDC transmission lines and towers located along the same Prime route as the Alaska Natural Gas Transportation System (Figs. 1.1.2.2-1 in the Canada volume, and 8-17). HVDC was chosen over HVAC for large loads over long distances because the HVDC has much greater power transfer per conductor and also lower line losses and it eliminates the need for the expensive and complex equipment for control of voltages and currents required by the HVAC system. At the common eastern destination, the power would then be converted to alternating current and distributed by expanded a.c. (alternating current) networks (CAGPL, 1974).

Each generating plant would receive 2,250 MMcfd (million cubic feet per day) of natural gas at contractual temperature, pressure, and quality. The Prudhoe Bay plant would have 28 500-MW generating units yielding a daily total of 931 BBtu or 297 x 106 Kwh. The Mackenzie Delta plant would have 27 500-MW generating units yielding a daily total of 879 BBtu or 258 x 106 Kwh. High pressure steam boilers, fueled by natural gas, would discharge steam through turbines, which in turn would drive the alternating current generators. This generator output would be transformed into HVAC and then converted to HVDC. About 1400 employees would be needed to operate and maintain each plant. The size of the area required would be much larger than the 200-acre LNG plants.

The HVDC transmission system would consist of six 4,000 MW (megawatts) + or - 600 KV (kilovolt) HVDC lines operating in the bipolar mode, that is, three from each source, and each line would need two sets of converter stations. The lines would be carried by towers 150 to 200 feet high, spaced from 1,400 to 1,600 feet apart on a right-of-way 900 to 1,200 feet wide and following approximately the same route as the natural gas pipeline. About 75,000 towers would be needed, having a variety of anchors and foundations depending upon the subsoil conditions. A supervisory system would be needed to detect and isolate line faults. The permanent staff required would probably be about 950.

Feasibility

Electrical generating plants and HVDC transmission lines are presently operating satisfactorily in various parts of the world. A number of 500-MW generating units are already in operation in various parts of the United States and Canada. The level of technical confidence in this system is considered to be very high.

Efficiency and cost are important factors to consider here. Based on an average daily delivery of 4918 BBtud (billion British thermal units per day), the net energy delivered to the consumer market would only be 1,481 BBtud or 30.1 percent while total energy losses would amount to 3,437 BBtud or about 70 percent. The HVDC system loses efficiency primarily at the generating plant which operates at only 36.8 percent with a loss of 63.2 percent while 3.75 percent is lost in both the conversion from HVAC to HVDC and again from HVDC to HVAC, and 11.8 percent is lost in the transmission lines. The efficiency of the HVDC system thus is about 30.1 percent as opposed to the 90 percent for the Alaska Natural Gas Transportation System. The total common destination capital cost for the HVDC system would be 2.5 times that of the gas pipeline and the total common destination operating cost would be five times greater.

An alternative possibility for obtaining HVAC for direct transmission to the consumer would be to transport by pipeline the total amount of gas produced daily to the eastern terminal and then convert it there to electricity. The efficiency then would be 36.8 percent x 90 percent = 33.1 percent. Although this figure sounds closer to the percentage cited above for the HVDC system, the two efficiencies would be approximately equal only if the end use of the electricity produced by both methods were for power. If the end use of both the unconverted natural gas and the HVDC system's electricity were to be for heating, the use of the natural gas would be more efficient, that is, 90 percent pipeline x 66 percent furnace = 59.4 percent, while for the electricity it would be 31 percent x 98 percent = 29.5 percent (CAGPL, 1974).

Using the basic formula, delivered efficiency x utilization efficiency = ultimate efficiency, for central heating, natural gas would give 90 percent x 75 percent = 67.9 percent and electricity, 17 percent x 95 percent = 16.1 percent; and used for heating 100 gallons of water per day, natural gas would given 98 percent x 63.7 percent = 59.2 percent and electricity, 17 percent x 92.2 percent = 15.6 percent (SCGCGPL, 1974).

Studies have also been made involving the use of a fuel cell in structures ranging in size from a mobile home to a large apartment complex or a factory. Natural gas would be delivered directly to these structures and a portion would be processed by the fuel cell to produce the electricity required for the building, while the rest would be used for other purposes in the form of gas. The cost might be about the same as that for present gas and electrical services but the method would produce pollution-free fuel supplies, for the fuel cell combines natural gas with oxygen from the air to produce the electricity directly without combustion. Another factor to consider is the present trend towards using fuel other than natural gas to produce electrical power.

Environmental Impact

The environmental impact of the HVDC transmission system, which would follow approximately the Prime route of the Alaska Natural Gas Transportation System, would be similar to the gas pipeline in some features and their environmental effects, which have been described earlier in this report in the Canada volume, Section 3 on the environmental impact and mitigating measures of the Canadian section of the Alaska Natural Gas Transportation System. Only additional differences will be included here.

Borrow pits would be left on the land surface from which material to build the foundations of the towers would be obtained. The exact amount of borrow material and the size of the borrows cannot be determined because the size of the foundations including their variations with different soils has not been specified, but a system requiring 75,000 towers would require a substantial amount.

The presence of the generating plants at Prudhoe Bay and Mackenzie Delta would mean that considerably more than 200 acres of land would be required for each plant. This would disturb the wildlife occupying the area because of the noise and dust created by the construction machinery and necessitate shifts in habitat from the area to be occupied by the plant facilities. An estimated permanent staff of 1400 would be required to maintain and operate each plant, thus involving additional land to set up housing and other service facilities to meet their needs. Teams of several thousand construction workers would be needed to build the plants over a period of six years and this labor force would require similar facilities but on a temporary basis. As the scale of such human activities multiplies, the inevitable environmental injury risk increases accordingly.

The effect on the marine environment of the Beaufort Sea area of an unspecified rise in temperature of sea water returned to the sea after being used for cooling in the steam-generating cycle of the plants would be similar to that described under the dense-phase alternative, except that the amounts of temperature rise and pass-through water are not specified, and the description need not be repeated here (Eisenbud and Gleason, 1970).

The construction of a reconversion plant in eastern Pennsylvania to change the HVDC to HVAC for transmission to consumers would involve land requirements similar to those already noted for the generating plants.

The HVDC lines and towers would traverse approximately the Prime route of the Alaska Natural Gas Transportation System and would introduce along it many similar environmental factors, such as disturbances caused by human access for inspection, maintenance, and repair by ground or air, with a permanent crew of 950 required for this purpose. Another important consideration is the fact that, while pipeline facilities are largely buried, the HVDC system requires towers 150 to 250 feet high with six transmission lines strung between them. These lines and towers would undoubtedly have a widespread and undesirable or objectionable aesthetic effect on the area scenery. They might well be a substantial hazard to the flight of birds, especially during the migration seasons.

Other environmental impacts often associated with HDVC transmission lines are a "zinging" noise caused by the lines. Ozone is frequently generated by high voltage transmission lines and sometimes causes degradation of air quality or possible oxidant damage to vegetation. Vegetation on the transmission right of way requires control, which is often achieved by defoliant spraying from helicopters. Overspraying might damage crops or injure cattle and other animals.

8-F-11. Summary of Environmental Impacts of Alternative Transportation Systems

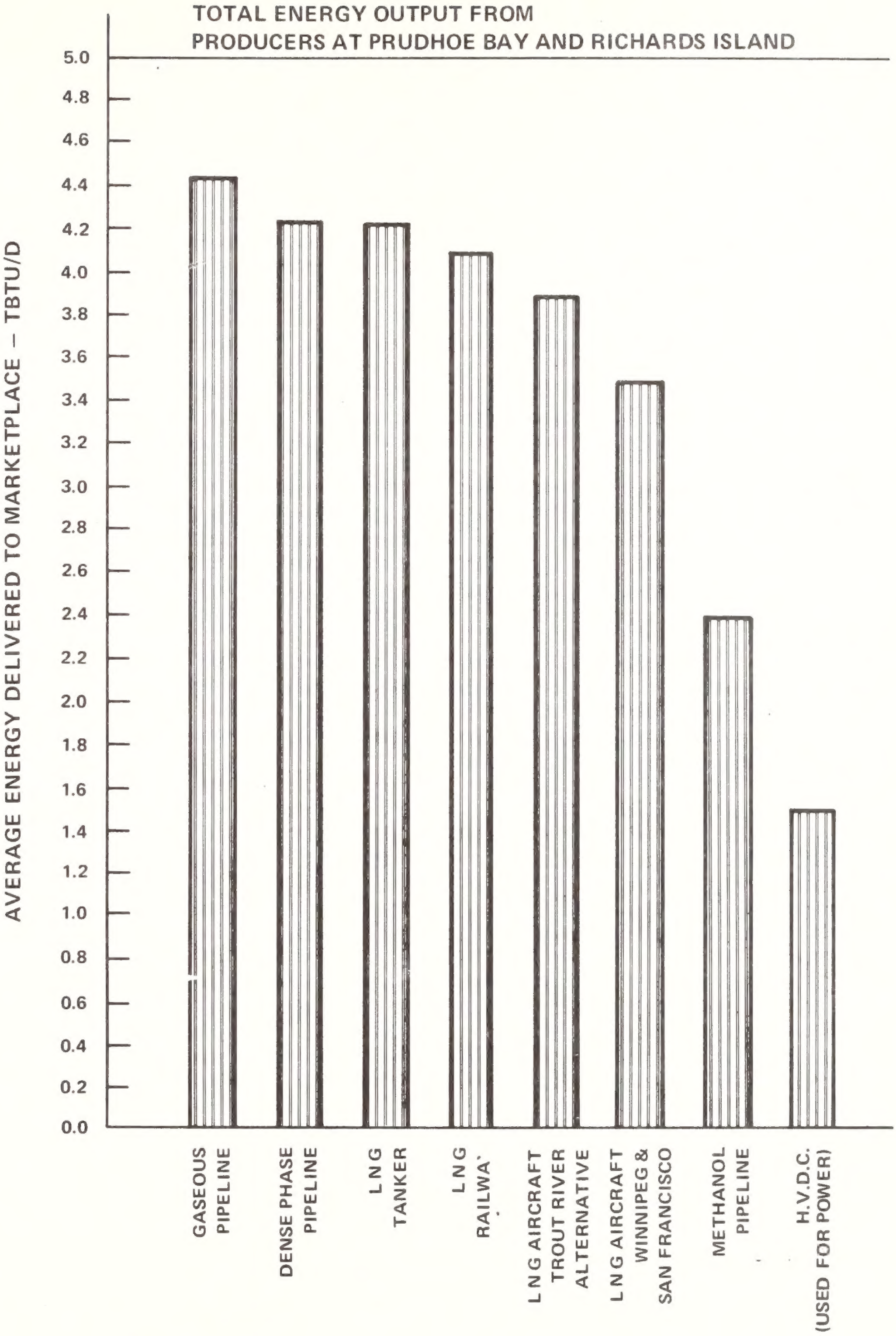
To properly assess the environmental impact of alternative transportation modes, a technical base must be available. Several of the systems described are not within current technology, and as such, any discussion of their environmental impact is extremely speculative. The systems considered outside current technology are LNG transport by the Helifloat, submarine, airplane, monorail, and dirigible. Other systems which seem to be much closer to state-of-the-art than the above are the ice-breaking tanker or the methanol submarine; however, these too were considered to require major development tasks for which many technical problems could not be predicted at the present time.

Therefore, while possible environmental impacts of these systems are mentioned briefly in the preceding sections, they will not be discussed in the summary. These are considered in graphic form in Figure 8-18 from the standpoint of energy efficiency.

The status of the long-term systems is as follows:

Helifloat--This is purely a concept at this time with unproven feasibility. Not enough is known of the concept to discuss the technical merits, particularly the remote control, arctic operation, etc.

Submarine--The technology to design and build a cryogenic LNG or a methanol submarine and the structural aspects of the system still require extensive development. No nuclear power plants are in use in the commercial marine industry and probably will require considerable time for development and licensing before being ready for use. Shipping the gas as methanol



Source.—Canadian Arctic Gas Pipeline Environmental Report. Sec. 14e

Figure 8-18 Net energy delivered to common destinations by Alaska Natural Transportation System and by some alternative transportation systems

would have some advantages over shipping it as LNG because submarines designed for carrying petroleum could be used to transport methanol. These concepts are not viable in a reasonable time frame (5-10 years) and the problems are not sufficiently defined to fully assess the environmental impacts. (The special problems associated with shipping methanol by the TAPS pipeline, a methanol pipeline, or submarine have been discussed in detail under the methanol pipeline and the submarine sections of this volume as well as in the Maritime Administration report (1975), so are not considered further in these discussions.)

Airplane--Years (5-10) of development are required to design and build a aircraft three times larger than the largest now in service, to which must be added novel cryogenic features. Large environmental impacts can be speculated about at both ends of the route. The pollutants which would be dumped into the atmosphere enroute can be quantified, but the concept is not viable in a reasonable time frame and the problems are not sufficiently defined to assess fully the environmental impacts.

Dirigible--No technology exists for this type of dirigible and even proponents of it expect ten to fifteen years of development time. While on the surface the system appears to offer less environmental impact than any of the above, it is not a viable system in a reasonable time frame and the hypothetical impacts will not be discussed.

Monorail--The technology here is at least five to ten years from providing an electric-magnetic float monorail system capable of carrying the loads discussed for this system. The environmental impact would be very similar to that of the railway except for some advantages resulting from elevation of the monorail above the ground.

Tanker--As noted, ice-breaking tankers are closer to state-of-the-art than the other systems outlined above. However, the technology for a cryogenic ice-breaking tanker of the size indicated clearly does not exist and major development is required. The problems are not sufficiently defined to assess the environmental impact of a tanker fleet.

The remaining alternative transportation systems considered in the preceding sections were the HVDC transmission system, the dense-phase gas pipeline, the methanol pipeline, and the railway. Sufficient technical understanding of the problems involved in these systems exists to provide a primarily qualitative evaluation of the environmental impacts. For example, if each of these transportation systems raises the temperature of the sea water at Prudhoe Bay, each system will create an impact on the marine life therein. With the available data, there is no way to state what direct effect each system has on each species of plant and animal life in the area; however, the system which discharges the greatest amount of heat into the ocean would have the greatest impact on the marine life.

This example in general is true for all of the environmental effects of the alternative transportation systems. The discussions below attempt to specify which systems cause the largest impact and to give an order of magnitude of the relative effect. The system, therefore, which causes the greatest change to the environmental element being discussed is said to have a large effect. This does not mean that the effect is known in absolute terms, but simply means that the system has the most effect compared to the other systems being considered.

Climate, Water, Air Quality, Noise and Vibration

Each of the alternative systems discussed here (HVDC transmission system, dense-phase gas pipeline, methanol pipeline, and railway), requires a plant or plants at the wellhead to convert the natural gas into another form, and a transportation system to deliver this product to the market place. These plants at the wellhead all consume natural gas to accomplish the work and the products of combustion are ejected into the atmosphere. Also, in each system, large amounts of water are required for cooling and/or steam generation. Heat and water (as well as other pollutants) are ejected directly into the atmosphere from the combustion process and heat is ejected into the water (ocean) from the waste feed water. Noise and vibration are also produced by these plants. All of these plants, therefore, affect the environment in a similar fashion and the magnitude of the effect is proportional to the amount of the energy consumed in the local area.

There is some difference in the size of the plants and work force. Should any of these alternatives be judged worthy of more serious comparison to the Alaska Natural Gas Transportation System, this factor should be considered in more detail.

For each of the transportation systems which delivers the product to the market, the impact on the environment depends upon the type of system; however, all systems discussed here originate and terminate at roughly the same location and follow approximately the same route. Therefore, the impacts of the systems can be compared directly with one another.

HVDC Transmission System--The conversion of natural gas to electrical energy requires the combustion of all of the gas to generate steam which, in turn, drives steam turbines to generate electricity. The products of combustion from 2.25 x 10^9 cfd of gas would be ejected into the atmosphere at each plant location (Prudhoe Bay and Mackenzie Delta). Thus, for this system, all water and other pollutants produced from combustion of the gas are concentrated in these two local areas. This must, therefore, cause a relatively large effect on air quality. For the gas pipeline system, only a fraction of 1 percent of the energy is used at the wellhead and the rest of the gas is consumed at thousands of plants and homes over a vast area. Because the process is only about 37 percent efficient, there will be a heat loss at each location of approximately 1.56 x 10^{12} Btud. The total system efficiency quoted by the applicant is 30 percent compared to 90 percent for the proposed gas pipeline. This means that seven times more energy is wasted by the HVDC system than by the gas pipeline. In ecological terms, this wasted energy is used to alter the environment. Most of the wasted energy is concentrated in two locations--at Prudhoe Bay and Mackenzie Delta, whereas the 10 percent wasted energy for the gas pipeline transmission system is used at the compressor sites distributed along the pipeline route.

The waste energy affects the local environment in many ways. Water required for the steam plant would be drawn from the ocean and waste heat would be ejected into this water and into the atmosphere. In winter, the heat ejected into the ocean and the warm moist air from the combustion process will both create conditions conducive to ice fog. The temperature rise of the coolant water and the atmosphere cannot be quantified on the basis of available information; however, it can be said that two plants covering at least an estimated 200 acres each will have a relatively large impact on the local water temperature, air temperature, humidity, air quality (pollutants), noise and vibration.

The rest of the HVDC transmission system will have a relatively small impact on climate, water, air quality, noise and vibration. Wind through the transmission lines and towers will create a variable background noise. Under some conditions, ozone will be generated by the high voltage lines which will change local air quality. In those areas where vegetation could affect the transmission lines, defoliant is often sprayed from helicopters and this also could have a temporary effect on air quality. These effects are judged to be small.

At the terminal end of the HVDC system, the electricity is converted to A.C. These plants are located in more industrialized areas and while they use land and generate noise, their impact on the environment (depending upon specific location) can be relatively small, if they are located adjacent to other similar industrial plants and not in a wilderness area.

Dense-Phase Pipeline--As discussed above, the plants required at Prudhoe Bay and Mackenzie Delta, are similar in their effect on the environment and only differ in degree. The dense-phase plants burn approximately 1.13 x 10^{12} cfd of gas at each location to produce dense-phase gas. This is the total amount of gas burned at each location compared to 2.25 x 10^{9} cfd burned at each HVDC electrical generating plant. Thus, the amount of air pollutants and water produced at the dense-phase processing plant is one-twentieth of the amount produced at the HVDC plants. The amount of heat energy ejected into the environment at each dense-phase plant would be 1.2 x 10^{12} Btud compared to 2.5 x 10^{12} for each HVDC plant. This is one-twelfth of the effect of the HVDC plant. These two plants, therefore, will have a moderate impact on water temperature, air temperature, humidity, air quality (pollutants), noise and vibration. These numbers are still much larger than the values for the proposed gas pipeline, which only change the local environment at Prudhoe Bay and Mackenzie Delta about one-tenth as much as the dense-phase system.

The effect of the rest of the dense-phase pipeline system on climate, water, air quality, noise and vibration is very similar to the effect of the gas pipeline. Approximately the same number of compressor stations are required to move the gas and the same amount of energy is required. Similar controls and valving will be required. The dense-phase pipeline is colder than the gas pipeline, and some lower ground and surface air temperature along the route would result, causing local effects. These are judged to be small except for the effect on water movement (drainage) which can be significant and is dependent upon details of design. (This is discussed under soils.)

The regasification plants located in southern Canada would consume about one-fifth of the energy required at Prudhoe Bay and Mackenzie Delta. The work is done entirely in the gas and no cooling water is required. The combustion products (pollutants and water) would be one-fifth of the dense-phase plants, but almost all of the heat energy would be used to heat the gas with very little waste heat ejected to the surroundings. These plants would be roughly equivalent in energy consumption to the compressor stations along the route and, therefore, the impact is judged to be small.

Methanol Pipeline--The methanol plants at Prudhoe Bay and Mackenzie Delta would have the same type of impacts on the environment as those discussed above, creating conditions conducive to ice fog, ejecting heat into the water and air, ejecting combustion products (water and pollutants) into the atmosphere and creating noise and vibration. These effects, as mentioned above, are proportional to the energy used for the conversion.

The energy required at each plant to convert the natural gas to methanol is approximately 1.04 x 10^{12} Btud or about two-thirds of the energy required for the HVDC electrical system discussed above. This amount of energy ejected at the two plants located at Prudhoe Bay and Mackenzie Delta, would have a relatively large impact on the climate, water quality, air quality, noise and vibration. In addition, as outlined below, the extraction of the water required for the conversion process would also have a large impact on the local environment.

In the conversion of natural gas to methanol, water is used directly in the process as super-heated steam mixed with the gas. It is assumed that this water must be fresh water. The applicant has not addressed this problem and has presented no data on the volume of fresh water required. A continuous supply of water is required, to convert the gas to methanol. This water would be removed from the Prudhoe Bay and Mackenzie Delta areas and transported to the pipeline destinations in California and Pennsylvania where the methanol would be transformed back to natural gas and water. This water withdrawal at the wellhead has a large impact. Because the volumes required have not been specified and the supply available is unknown and perhaps insufficient, especially in winter when most of the fresh water supply is frozen, this factor may make the conversion of natural gas to methanol infeasible.

The effect of the rest of the methanol pipeline transportation system on climate, water, air quality, noise and vibration would be very similar to the effect of the gas pipeline. Approximately the same number of compressor stations are required to move the methanol and approximately the same amount of energy as required. The pipeline would be 36 inches in diameter instead of 48 inches, which is a minor factor. Similar valving and controls would be required. The pipeline would operate at the same temperatures as the gas pipeline. These effects are all very close to the effects of the gas pipeline and judged to be small. At the terminal end of the methanol pipeline, a tank farm would store the methanol. These tank farms would be sufficient to hold one day's production. Because no tank farms are proposed for the gas pipeline system, this represents an additional impact to the local area. (Approximately 1,000,000 barrels total capacity at the three locations.) These farms would not affect the climate, water, air quality, noises or vibration. To convert the methanol to synthetic natural gas would require approximately one-fifth of the energy required to produce the methanol at Prudhoe Bay and Mackenzie Delta. This should be a small impact in these vast energy consuming areas. Water will be recovered in this process, which could be used beneficially in the Los Angeles area.

Railway--The railway transportation system requires liquid natural gas plants at Prudhoe Bay and Mackenzie Delta. These plants will have the same type of effects as discussed above for the three other systems, creating conditions conducive to ice fog; ejecting heat into the water and air; ejecting combustion products (water and pollutants) into the atmosphere; and creating noise and vibration. These effects, as stated before, are proportional to the energy required for the conversion.

The energy required at each plant to liquify the natural gas is approximately one-fourth of the energy required for the HVDC electrical system discussed above. The amount of pollutants and water ejected into the atmosphere for the LNG plants would be approximately one-eleventh of the amount produced by the HVDC electrical generating plants. These numbers are much larger, however, than those for the proposed gas pipeline, which only changes the local environment at Prudhoe Bay and Mackenzie Delta about one-thirtieth as much as the LNG system. These two plants will have a moderate to high impact on water temperature, air temperature, humidity, air quality (pollutants), noise and vibration.

The effect of the railway transportation system on the climate, water quality and air quality along the right-of-way would be small. The effect on drainage will be discussed below under soils.

The schedule of twelve one-hundred-car trains moving in each direction per day would leave very little time free from the noise and vibration of an approaching or departing vehicle. Noise and vibration along the right-of-way will have a large impact in these areas--especially since these are remote wilderness areas unaccustomed to the noise produced by industrial equipment. Storage capacity at the Trout River destination would be 1.8 million barrels. This tank farm would have little effect on the factors discussed in this section. The LNG would then be heated to a gas and transported to the destination points via a pipeline possessing the same features and following the same route as in the applicant's gas pipeline proposal. Thus, the impacts from Trout River to the destination points are the same as for the proposed gas pipeline.

Topography, Geology and Soils

All four alternative transportation systems follow approximately the same route as the proposed Alaska Natural Gas Transportation System so that from a technical standpoint, problems posed in design of these systems by environmental factors are similar. For instance, the seismic activity levels which those systems must survive are the same, but in each instance the solution to the problem depends upon the type of structure required. These are all engineering problems imposed by the environment and it will be assumed here that these problems are all solvable, without attempting to evaluate whether one system is more easily adapted to the environment than the other. The discussion below will be confined to the effects of the systems on the topography, geology, and soils.

HVDC Transmission System--The HVDC system would have little effect on the geology, topography and soils. Electrical generating plants installed at Prudhoe Bay and Mackenzie Delta would each occupy at least 200 acres and the topography of these sites would be altered. The major changes would be in and around buildings and roadways constructed on each site. The transmission system only requires land for each of the towers which support the cables and this land would be altered very little to support the tower foundations. Relative to the gas pipeline, which affects the topography for several thousand miles, the HVDC system effect is small. The aesthetics are discussed elsewhere.

Dense-Phase Pipeline--The effects of the dense-phase pipeline system on geology, topography and soils are judged to be moderate. This system requires about 50- to 100-acre plant areas both at Prudhoe Bay and Mackenzie Delta. Pipeline effect on topography is the same as that of the gas pipeline. There will probably be increased problems with drainage due to the -150°F operating temperature of the pipeline vs. the +31°F for the gas pipeline. Assuming this technical problem can be solved, this should be only a small additional factor. Soils, however, will be frozen to a larger extent than under the gas pipeline system and this will affect items other than drainage which are discussed elsewhere.

Methanol Pipeline--The effect of the methanol pipeline system on geology, topography, and soils is judged to be moderate. This system requires approximately 100- to 150-acre plant areas both at Prudhoe Bay and Mackenzie Delta. The effect of the methanol pipeline system on topography is almost identical to that of the gas pipeline system because it follows the same route and is similar in all features.

Railway--The effect of the railway system on geology, topography and soils is judged to be very large. This system requires approximately 200-acre plant areas both at Prudhoe Bay and Mackenzie Delta, along the lines of those in the other three systems, so that the impacts on topography are similar. The railway roadbed provides a much more dramatic impact on the topography than any of the pipeline systems. The roadbed is limited to a grade of less than .5 percent which requires much more cut-and-fill operations or a much longer right-of-way or more likely as a combination of both than for the pipeline systems. The roadbed poses a significant problem to surface drainage, but it is possible that this problem is solvable.

Vegetation and Wildlife

The effect of each of the transportation systems on vegetation and wildlife can be reduced for the most part to the relative area of land removed from use for support of vegetation or wildlife and the relative disturbing effects a given transportation system may have on wildlife.

HVDC Transmission System--In the systems discussed above, the HVDC electrical transmission system would have the least effect on vegetation. The total area required by the generating plants and the tower foundations is much smaller than any of the other systems including the proposed gas pipeline. Thus, the effect on vegetation and wildlife (in terms of available habitat and food stuffs) is small. Wildlife may be disturbed somewhat by the sound of the wind through the wires or, during migration, birds may be disturbed by the wires themselves, but these too are considered small effects. The effect of migrating birds flying into the towers may be larger.

Dense-Phase Pipeline--The dense-phase pipeline system operates at -150°F. Assuming the same depth of burial as for the gas pipeline operating at less than 32°F, the ice ball will probably be larger. This would probably keep the soil at the surface frozen throughout the year and prevent effective revegetation all the way to the regasification points at Monchy and Kingsgate. This approximately 2,000-mile corridor 10 to 20 feet wide would effectively be removed as habitat for wildlife and be barren of food stuff. This is judged to be a large effect on wildlife and vegetation.

Methanol Pipeline--This system is almost identical in its impact upon vegetation and wildlife to the proposed gas pipeline. The methanol pipeline would operate at the same temperature and cover the same route as the proposed pipeline system. The impact on wildlife and vegetation is judged to be moderate.

Railway--For this system the vegetation along the roadbed would be obliterated all the way to Trout River. This entire roadbed would be removed as habitat to wildlife. The noise and vibration produced by the trains probably would increase the area lost to wildlife by more than an order of magnitude. These trains also present a hazard to wildlife. The impact of the railway on vegetation and wildlife is judged to be very large.

Economic, Sociological, Recreational and Aesthetic Factors

The subject of this section is very broad if one chooses to consider all of the ramifications of each of these systems. To reduce this to a scope which can be handled briefly, it is assumed that the system which costs the least in terms of installation, operation and loss of natural resources has the least economic impact; that the system which uses the least manpower for construction and operation has the least sociological impact; that the system that occupies the least area has the least recreational impact; and that the system which is the least obtrusive has the least aesthetic impact.

HVDC Transmission System--The applicant estimates that the HVDC system is twice as expensive and only one-third as efficient as the gas pipeline. Operating costs are five times as high--primarily because of the larger numbers of operating crews required. The HVDC system therefore poses a large economic and sociological impact. Because it uses the least land area, it has a small impact on recreation.

The transmission towers are obtrusive and some noise results from the wind through the wires so that the aesthetic impact is judged to be large.

Dense-Phase Pipeline--The dense-phase pipeline costs about 50 percent more to install and operate than the gas pipeline and it is slightly less efficient. The economic and sociological impacts are, therefore, judged to be relatively small. The land which is affected by the dense-phase pipeline (from Alaska to Kingsgate and Monchy) is considerable and those portions in southern Canada that are normally accessible for recreation purposes will be lost because of the probable lack of vegetation discussed above. This loss of vegetation will also affect aesthetics. The impact on recreation and aesthetics is, therefore, judged to be moderate.

Methanol Pipeline--The methanol pipeline system costs about 50 percent more to build and 200 percent more to operate than the gas pipeline. It is only 60 percent as efficient. The economic and sociological impact of the methanol pipeline is therefore judged to be moderate.

The effect on recreational area and aesthetics is the same as for the gas pipeline. This impact is judged to be small.

Railway--The railway system is approximately twice as expensive to build and five times as expensive to operate. In energy terms it is 50 percent as efficient as the proposed pipeline. The economic and sociological impact of the Railway is judged to be large.

The entire roadbed is made unavailable for recreational use, but it is located north of Trout River in northern Canada so that its actual impact on recreation is judged to be small.

The entire roadbed also has a large impact on aesthetics from an absolute standpoint, but because it is located in a remote area and aesthetics is a human appreciation term, the impact of the railway on aesthetics is judged to be small.

Historic, Archeological, and Land Use

The historic and archeological impacts of these systems will be roughly proportional to land use. In addition, the impacts will be proportional to the amount of material excavated. Assuming, however, that historic and archeological items will be uncovered and thus our store of knowledge will be increased, these large impacts could be judged beneficial to man. On the other hand, the railway roadbed will cover large tracts of right-of-way under fill and make them unavailable for historic or archeological finds. This large impact to "potential" historic and archeological finds could be judged as detrimental or a loss of potential knowledge to man. For the purpose of this assessment, the beneficial effects will not be considered and only the detrimental impacts will be evaluated.

HVDC Transmission System--Because the electrical generation plants need to consume the entire gas delivery of the wells at each location but do not require the storage systems needed for the LNG or methanol systems, it will be assumed that each plant is roughly equivalent to at least the 200 acres required for the LNG system. The rest of the transmission system requires towers spread 1400 to 1600 feet apart along the right-of-way. Thus, the land which is made unavailable for archeological or historic research is primarily that land covered by the plants at Prudhoe Bay and Mackenzie Delta. The impact on land use and historic and archeological factors is judged to be small.

Dense-Phase Pipeline--The installation at Prudhoe Bay and Mackenzie Delta required to process the dense-phase gas is approximately 50 to 100 acres at each location. The pipeline will be buried and make any historical or archeological items along the right-of-way available for immediate discovery.

Compressor sites along the right-of-way would make additional land unavailable for exploration. The impact of the dense-phase pipeline on land use and historic and archeological factors is judged to be moderate.

Methanol Pipeline--The factors mentioned under dense-phase pipeline would be applicable to the methanol pipeline and the impact on land use and historic and archeological factors would be the same.

Railway--The LNG plant area required at Prudhoe Bay and Mackenzie Delta is estimated to be 200 acres at each location. The entire roadbed of 2,065 miles would be buried and unavailable for exploration. Some of this distance would be excavated in cut-and-fill operations exposing some subsurface to immediate exploration but the major portions will be buried and none will be available for agriculture or vegetation. The impact of the railway on land use and historic and archeological factors is judged to be very large.

Hazards and Safety

In the following discussion the assumption is made that each system would be designed to the best standards available and that the probability of malfunction would be equal for all systems. Using this assumption it is possible to gage the relative hazard in terms of human safety because it can be assumed that those systems which require the largest operating crews would provide the greatest chance of injury to the workers. (Not necessarily any worse, however, than another industrial operation employing the same number of people.)

HVDC Transmission System--A large industrial complex would be required at Prudhoe Bay and Mackenzie Delta to convert the gas into electrical power. The applicant estimates 1,400 employees would be needed to operate and maintain each plant and 950 employees would be needed to maintain the transmission lines. The major hazard is from all types of industrial accidents within the plant area, and injury from exposure to the environment or falls for the employees maintaining the transmission lines. This system requires the largest number of employees of all of the systems discussed and from the standpoint of largest exposure, it is judged that this system presents a large relative hazard to safety.

Dense-Phase Pipeline--The dense-phase plants located at Prudhoe Bay and Mackenzie Delta each require about 300 employees, according to the applicant's estimate. The applicant does not state, but it is assumed that the rest of the pipeline would be primarily automatic as is the proposed gas pipeline. No estimate was given for employees at the Kingsgate and Monchy locations, but it is assumed that each of these plants would employ 100 or more people. This is significantly fewer total people than the 3,750 people estimated for the HVDC system and, therefore, presents a moderate hazard to safety.

Methanol Pipeline--The methanol system would require plants at Prudhoe Bay and Mackenzie Delta employing approximately 700 at each location, according to the applicant's estimate. The applicant does not state, but it is assumed that the rest of the pipeline would be primarily automatic as is the proposed gas pipeline. No estimate was made for employees at the synthetic natural gas (SNG) plants located in the terminal area. These plants may require as many employees as the wellhead plants. This would involve approximately as many people as the HVDC system and, thus, presents a relatively large hazard to safety.

Railway--The applicant estimates that a labor force of over 500 would be required at each LNG plant. No estimates were given for operation of the railway or the regasification plants; however, a total labor force would probably be about 3,000. This makes the system comparable to the HVDC and methanol pipeline systems and, in terms of hazard to humans, the railway presents a relatively large safety hazard. The hazard to wildlife is also large.

8-F-12. References

Alaska Arctic Gas Pipeline Company (AAGPC), 1974, Environmental Report of Alaska Arctic Gas Pipeline Company (Chapter V).

American Association of Petroleum Geologists, 1971, Future petroleum provinces of the United States-- Their geology and potential, (I.H. Cram, ed.): Am. Assoc. Petroleum Geologists Mem. 15, v. 1, p. 1-803; v. 2, p. 805-1496.

Anderson, L.L., 1972. Energy potential from organic wastes--A review of the quantities and sources: U.S. Bur. Mines Inf. Circ. 8549.

Arctic Institute of North America, 1974, The Alaskan Arctic Coast--A background study of available knowledge: Report prepared for U.S. Dept. Army, Alaska District, Corps of Engineers, 551 p.

Atwood, Genevieve, 1975, The strip-mining of Western Coal: Scientific American, v. 233, no. 6, December, p. 23-29.

Averitt, Paul, 1975, Coal resources of the United States, January 1, 1974: U.S. Geol. Survey Bull. 1412, 131 p.

Averitt, Paul, and Carter, M.D., 1970, Selected sources of information on United States and World energy resources--An annotated bibliography: U.S. Geol. Survey Circ. 641, 21 p.

Axtmann, R.C., 1975, Environmental impact of a geothermal power plant: Science, v. 187, no. 4179, March 7, p. 795-803.

Barnea, Joseph, 1972, Geothermal power: Scientific American, v. 226, no. 1, January, p. 70-77.

Beck, E.J., 1975, Ocean thermal gradient hydraulic power plant: Science, v. 189, no. 4199, July 25, p. 293-294.

Bethe, H.A., 1976, The necessity of fission power: Scientific American, v. 234, no. 1, January, p. 21-31.

Biederman, N.P., 1970, Natural gas by airfreight?: Pipeline and Gas Journal, v. 197, no. 12, p. 62, 64, 69. (Summary of paper presented by Miles H. Sonstegaard on "Transporting of commercial gases by airship.")

Bond, T.P., 1974, Airships [Letter]: Science, v. 185, no. 4157, Sept. 27, p. 1109-1110.

California State Assembly, Committee on Resources, Land Use, and Energy, 1975, Energy alternatives for California--Paths to the future (Executive summary): Report R/1793/1--CSA/RF (Preliminary), prepared by the Rand Corporation, Sept. 25, 1975, 62 p.

Cambel, A.B., 1964, Energy research and development and national progress: Washington, D.C., Executive Office of the President, Office of Science and Technology, 435 p.

Campbell, J.A., 1975, Oil-impregnated sandstone deposits of Utah: Mining Engineering, v. 27, no. 5, May, p. 47-51, 53.

Canadian Arctic Gas Pipeline Limited (CAGPL), 1974, Alternative Corridors and Systems of Transportation, Section 14.e.

Colp, J.L., 1974, Magma-Tap--The ultimate geothermal energy program: Sandia Laboratories, Albuquerque, N.M.; Circum-Pacific Energy and Mineral Resources Conference, Honolulu, Hawaii, August 28, 1974, 19 p.

Cram, I.H., ed., 1971, Future petroleum provinces of the United States--Their geology and potential: Am. Assoc. Petroleum Geologists Mem. 15, v. 1, p. 1-803; v. 2, p. 805-1496.

Culbertson, W.C., and Pitman, J.K., 1973, Oil shale, in U.S. mineral resources: U.S. Geol. Survey Prof. Paper 820, p. 497-503.

DeCarlo, J.A., Sheridan, E.D. and Murphy, Z.E., 1966, Sulfur content of U.S. coal: U.S. Bureau of Mines Inf. Circ. 8312.

Duffie, J.A., and Beckman, W.A., 1976, Solar heating and cooling: Science, v. 191, no. 4223, January 16, p. 143-149.

Duncan, D.C., and Swanson, V.E., 1965, Organic-rich shale of the United States and world land areas: U.S. Geol. Survey Circ. 523, 30 p.

Dupree, W.G., Jr., and Corsentino, J.S., 1975, United States Energy through the year 2000 [Revised]: U.S. Dept. Interior, Bur. Mines, 65 p. (Revision of 1972 version).

Eisenbud, Merril, and Gleason, George, eds., 1970, Electric power and thermal discharges (Papers presented at Symposium on "Thermal Considerations in the Production of Electric Power," sponsored by Atomic Industrial Forum and the Electric Power Council on Environment, Washington, D.C., June 1970): New York, Gordon and Breach, Science Publishers, Inc., 423 p.

El Paso Alaska Company, 1974, Environmental impact of the proposed action, Vol. 5 of Application of El Paso Alaska Company before the Federal Power Commission respecting the proposed Trans-Alaska Gas Project.

Ellis, A.J., 1975, Geothermal systems and power development: American Scientist, v. 63, Sept.-Oct., p. 510-521.

Energy Research and Development Administration (ERDA), 1975, A National Plan for energy research, development, and demonstration--Creating energy choices for the future, Vol. I, The Plan: Energy Research and Development Administration Report ERDA-48.

Energy Research and Development Administration, Division of Solar Energy, 1975, National Solar Energy Research, Development and Demonstration Program--Definition Report, ERDA-49, 79 p.

Faltermeyer, Edmund, 1975, The clean synthetic fuel that's already here: Fortune Magazine, September, p. 147-154.

Fay, J.A., and MacKenzie, J.J., 1972, Cold cargo: Environment, v. 14, no. 9, p. 21-29.

Federal Energy Administration (FEA), 1975, Draft Environmental Impact Statement--Energy Independence Act of 1975 and related tax proposals, DES-75.

Federal Energy Administration (FEA), Interagency Task Force on Coal, 1974, Coal--Project Independence Blueprint, Final Task Force Report: Washington, D.C.

Federal Energy Administration (FEA), Interagency Task Force on Natural Gas, 1974, Natural Gas-- Project Independence Blueprint, Final Task Force Report: Washington, D.C.

Federal Energy Administration (FEA), Interagency Task Force on Oil Shale, 1974, Potential future role of shale oil--Prospects and Constraints--Project Independence Blueprint, Task Force Final Report: Washington, D.C.

Federal Power Commission (FPC), 1971, National Power Survey.

Federal Power Commission (FPC), 1972, Hydroelectric Power Resources of the United States, Developed and Undeveloped.

Federal Power Commission (FPC), 1973, News Release No. 19370.

Federal Power Commission (FPC), 1974, Staff report on the role of hydroelectric developments in the nation's power supply.

Federal Power Commission (FPC), 1975a, Alaska Natural Gas Transportation Systems--Draft Environmental Impact Statement for the Alaskan Arctic Natural Gas Transportation System, Volume I-III: Washington, D.C., Federal Power Commission.

Federal Power Commission (FPC), 1975b, National Gas Survey, Vol. I, The Commission Report; Washington, D.C., Federal Power Commission, 387 p.

Federal Power Commission (FPC), 1975c, Report on fuel costs, October 1974.

Federal Power Commission (FPC), Bureau of Power, 1973, Staff report on wind power, 10 p.

Finch, W.I., and others, 1975, Discussion of Uranium Availability and the Breeder Decision: Energy Systems and Policy, v. 1, no. 3, p. 259-269. (Discussion of Holdren, J.P., 1975).

Fuller, J.G., 1975, We almost lost Detroit: New York, Reader's Digest Press, 272 p.

Gillette, R., 1974, Oil and Gas resources--Did U.S.G.S. gush too high?: Science, v. 185, no. 4146, July 12, p. 127-130.

Gregory, D.P., 1973, The hydrogen economy: Scientific American, v. 228, no. 1, January, p. 13-21.

Griffith, Winthrop, 1975, Blood, toil, tears and oil--How Boomtown greed is changing Alaska: New York Times Magazine, July 27, p. 8-9, 38-41.

Grossling, B.F., 1973, An appraisal of the prospects of geothermal energy in the United States, in U.S. Energy Outlook--New energy forms: Washington, D.C., National Petroleum Council.

Guccione, Eugene, 1975a, Leading physicist recommends coal and nuclear power [Interview with Hans A. Bethe]: Mining Engineering, v. 27, no. 5, May, p. 42-47.

Guccione, Eugene, 1975b, Oil shale suffers setbacks: Mining Engineering, v. 27, no. 5, May, p. 53-54.

Guccione, Eugene, 1975c, The obstacles to coal development: Mining Engineering, v. 27, no. 5, May, p. 34-37.

Hamilton, Roger, 1975, Can we harness the wind?: National Geographic Magazine, v. 148, no. 12, December, p. 812-828.

Hammond, A.L., 1974, Individual self-sufficiency in energy: Science, v. 184, no. 4134, April 19, p. 278-282.

Hammond, A.L., Metz, W.D., and Maugh, T.W., II, 1973a, Alternative energy sources, chap. 8 in Energy and the future: Washington, D.C., Am. Assoc. Advancement of Science, p. 47-53.

Hammond, A.L., Metz, W.D., and Maugh, T.W., II, 1973b, Fuel from wastes--A renewable energy resource, chap. 12 in Energy and the future: Washington, D.C., Am. Assoc. Advancement of Science, p. 73-78.

Hammond, A.L., Metz, W.D., and Maugh, T.W., II, 1973c, Magnetohydrodynamic power, more efficient use of coal, chap. 4 in Energy and the future: Washington, D.C., Am. Assoc. Advancement of Science, p. 25-28.

Heath, C.E., 1973, Fuel cells [Letter]: Science, v. 180, no. 4086, May 11, p. 542. (Reply to Maugh, 1972.)

Hendricks, T.A., 1965, Resources of oil, gas and natural-gas liquids in the United States and the world: U.S. Geol. Survey Circ. 522, 20 p.

Heronemus, W.E., 1972, The U.S. energy crisis--Some proposed gentle solutions: Congressional Record, Feb. 2, p. E1043-E1049.

Hittman Associates, Inc., 1974-1975, Environmental impacts, efficiency, and cost of energy supply and end use, Final Report, Vol. 1, 1974; Vol. 2, 1975: Columbia, Md., Hittman Associates, Inc.

Holdren, J.P., 1975, Uranium Availability and the Breeder Decision: Energy Systems and Policy, v. 1, no. 3, p. 205-232. (For discussion, see Finch, W.I., and others, 1975.)

Hooker, P.R., and Marsden, S.S., 1975, An improved method for transportation of oil and gas in the Arctic: Stanford University, Stanford, Calif. (Manuscript under consideration for publication.)

Hubbert, M.K., 1971, The energy resources of the Earth: Scientific American, v. 225, no. 3, September, p. 60-70.

Hubbert, M.K., 1974, U.S. energy resources, a review of 1972, Part 1, in A national fuels and energy policy study: U.S. Cong., 93d, 2d sess., Senate Comm. Interior and Insular Affairs, Comm. Print, no. 93-40 (92-75), 267 p.

Inglis, D.R., 1973, Nuclear energy--Its physics and its social challenge: Reading, Mass., Addison-Wesley Pub. Co.

Institute for Energy Analysis, Oak Ridge Associated Universities, 1975, Alaskan methanol concept--A Pre-feasibility study: Institute for Energy Analysis Research Memorandum IEA(M)-75-5, 223 p. (Report prepared for the Federal Energy Administration.)

Interagency Coal Task Force, 1974, Reserve preliminary data.

Jacoby, C.H., and Paul, D.K., 1974, Salt domes as a source of geothermal energy: Mining Engineering, v. 26, no. 5, May, p. 34-39.

Jensen, E.J., and Ellis, H.S., 1967, Pipelines: Scientific American, v. 216, no. 1, January, p. 62-70, 72.

Joint Association Survey of the U.S. Oil and Gas Producing Industry (JAS), November, 1971.

Kash, D.E., White, I.L., and others, 1973, Energy under the oceans--A technology assessment of Outer Continental Shelf oil and gas operations: Norman, Okla., University of Oklahoma Press.

Kilpatrick, J.J., 1975, Lighter-than-air is a heavy proposition: Washington Star, July 19.

Kolm, H.H., and Thornton, R.D., 1973, Electromagnetic flight: Scientific American, v. 229, no. 4, October, p. 17-25.

Krenkel, P.A., and Parker, F.L., eds., 1969, Biological aspects of thermal pollution (Proceedings of National Symposium on Thermal Pollution, sponsored by Federal Water Pollution Control Administration and Vanderbilt University, Portland, Ore., June 1968): Nashville, Tenn., Vanderbilt University, Press, 407 p.

Kruger, Paul, and Otte, Carel, eds., 1973, Geothermal energy--Resources, production, stimulation: Stanford, Calif., Stanford University Press, 360 p.

Kubo, A.S., and Rose, D.J., 1973, Disposal of nuclear wastes: Science, v. 182, no. 4118, December 21, p. 1205-1211.

Leverson, M.K., 1967, Geology of petroleum: San Francisco, W.F. Freeman and Co., 724 p.

Library of Congress, Congressional Research Service, Economics Division, 1974, Economic impact report on deregulation of natural gas: Library of Congress, Nov. 5, 1974, 16 p. (Report prepared by Lawrence Kumins, Analyst in Energy Economics, for the Honorable John E. Moss, Committee on Government Operations, House of Representatives.)

MacAvoy, P.W., and Pindyck, R.S., 1973, Alternative regulatory policies for dealing with the natural gas shortage: The Bell Journal of Economics and Management Sciences, Autumn issue, v. 4, no. 2, p. 454-498.

McConville, L.A., 1975, The Athabasca tar sands: Mining Engineering, v. 27, no. 1, January, p. 19-38.

McIntyre, H.C., 1975, Natural-uranium heavy-water reactors: Scientific American, v. 233, no. 4, October, p. 17-27.

McKelvey, V.E., 1973, Mineral resource estimates and public policy, in Mineral resources of the United States: U.S. Geol. Survey Prof. Paper 820, p. 9-19.

McKelvey, V.E., 1974, U.S.G.S. releases revised U.S. oil and gas estimates: U.S. Geol. Survey News Release, March 26, 1974.

McKelvey, V.E., 1975, New Estimates of nation's oil and gas resources: U.S. Geol. Survey News Release, May 7, 1975.

McNay, L.M., 1970, Coal refuse fires, an environmental hazard: U.S. Bureau of Mines, p. 8.

Maugh, T.H., II, 1972, Fuel cells--Dispersed generation of electricity: Science, v. 178, no. 4067, December 22, p. 1273-1274B.

Metz, W.D., 1973, Ocean temperature gradients--Solar power from the sea: Science, v. 180, no. 4092, June 22, p. 1266-1267.

Miller, B.M., and others, 1975, Geological estimates of undiscovered recoverable oil and gas resources in the United States: U.S. Geol. Survey Circular 725, 78 p.

Mining Engineering, 1974, AEC estimates rise in U.S. uranium reserves to be 4000 net tons: Mining Engineering, v. 26, no. 5, May, p. 5.

Mostert, Noel, 1974, Supership: New York, Alfred A. Knopf, Inc., p. 322-326.

Muffler, L.J.P., 1973, Geothermal resources, in United States mineral resources: U.S. Geol. Prof. Paper 820, p. 251-261.

National Academy of Sciences, National Research Council, Committee on Mineral Resources and the Environment (COMRATE), 1975, Mineral resources and the environment: Washington, D.C., National Academy of Sciences, 348 p. and 4 appendices.

National Petroleum Council (NPC), 1974, U.S. Energy Outlook--Oil and gas availability: Washington, D.C., National Petroleum Council.

National Petroleum Council (NPC), Coal Task Group, 1971, An initial appraisal, 1971-1985, in U.S. Energy Outlook, Vol. II, p. 136.

National Petroleum Council (NPC), Committee on U.S. Energy Outlook, 1972, U.S. Energy Outlook: Washington, D.C., National Petroleum Council, 381 p.

National Petroleum Council (NPC), Committee on Energy Outlook, 1973a, U.S. Energy Outlook--Oil and gas availability: Washington, D.C., National Petroleum Council.

National Petroleum Council (NPC), Committee on U.S. Energy Outlook, Other Energy Resources Subcommittee, New Energy Forms Task Group, 1973b, U.S. Energy Outlook--New Energy Forms: Washington, D.C., National Petroleum Council.

Nininger, R.D., 1973, Uranium reserves and requirements, in Nuclear fuel resources and requirements: U.S. Atomic Energy Commission Rept. WASH-1243, p. 10-28. (Adapted from speech before Atomic Industrial Forum, Uranium Seminar, March 1973.)

Novick, Sheldon, 1969, The careless atom: Boston, Houghton Mifflin Co., 225 p.

Olds, F.C., 1973, Capital cost calculations for future power plants: Power Engineering, January, p. 61-65.

O'Toole, Thomas, 1975, Short supply of uranium is predicted: Washington Post, December 10.

Parker, F.L., and Krenkel, P.A. eds., 1969, Engineering aspects of thermal pollution (Proceedings of National Symposium on Thermal Pollution, sponsored by Federal Water Pollution Control Administration and Vanderbilt University, Nashville, Aug. 1968): Nashville, Tenn., Vanderbilt University Press, 351 p.

Patton, A.R., 1975, Solar energy for heating and cooling of buildings: Park Ridge, N.J., Noyes Data Corp., 327 p.

Peterson, E.W., 1974, Wind power [Letter]: Science, v. 185, no. 4150, August 9, p. 480.

Péwé, T.L., 1975, Permafrost--Challenge of the Arctic, in 1976 Yearbook of science and the future: Chicago, Encyclopedia Britannica, Inc., p. 90-104.

Potential Gas Committee, 1973, Potential supply of natural gas in the United States (as of December 31, 1972): Colorado School of Mines Foundation, Inc., Mineral Resources Institute, Potential Gas Agency, 48 p.

Reed, T.B., and Lerner, R.M., 1973, Methanol--A versatile fuel for immediate use: Science, v. 182, no. 4119, December 28, p. 1299-1304.

Report of the Task Force Energy Conversion Research to the Technical Advisory Committee on Research and Development, April, 1974.

Resources for the Future, 1971, Energy research needs.

Revesz, A.G., 1973, Fuel Cells [Letter]: Science, v. 180, no. 4086, May 11, p. 542, 544. (Reply to Maugh, 1972.)

Rex, R.W., and Howell, D.J., 1973, Assessment of U.S. Geothermal Resources, in Geothermal energy--Resources, production, stimulation: Stanford, Calif., Stanford University Press, p. 59-60.

Rose, D.J., 1974, Energy policy in the U.S.: Scientific American, v. 230, no. 1, January, p. 20-29.

Seaborg, G.T., and Bloom, J.L., 1970, Fast breeder reactors: Scientific American, v. 223, no. 5, November, p. 14-21.

Shaw, Tom, 1975, Tidal power and the environment: New Scientist, v. 68, October 23, p. 202-204, 206.

Smil, Vaclay, 1974, Energy and the environment, scenarios for 1985 and 2000: The Futurist, v. VIII, no. 1, February, p. 4-13.

Smith, F.A., Sr., 1974, Transportation, in 1975 Yearbook of science and the future: Chicago, Encyclopedia Britannica, Inc., p. 330.

Sørensen, Bent, 1975, Energy and resources [Solar and wind energy in Denmark]: Science, v. 189, no. 4199, July 25, p. 255-260.

Southern California Gas Company (SCGCPL), 1974, Environmental Data Statement Project 73-663, A National Gas Pipeline, Nevada-California Border to Cajon, California, Table B. 4. 2-1.

Summers, C.M., 1971, The conversion of energy: Scientific American, vol. 225, no. 3, September, p. 149-160.

Theobald, P.K., Schweinfurth, S.P., and Duncan, D.C., 1972, Energy resources of the United States: U.S. Geol. Survey Circ. 650, 27 p.

Thurlow, E.E., 1974, Western coal: Mining Engineering, v. 26, no. 5, May, p. 30-33.

Time Magazine, 1975a, Energy--Row over scarce gas: Time, Oct. 13, p. 61.

Time Magazine, 1975b, The great nuclear debate: Time, December 8, p. 36, 41.

U.S. Atomic Energy Commission, 1973, Nuclear fuel resources and requirements: U.S. Atomic Energy Comm. Rept. WASH-1243.

U.S. Atomic Energy Commission, 1974a, Nuclear power 1974-2000: U.S. Atomic Energy Comm. Rept. WASH-1139-74.

U.S. Atomic Energy Commission, 1974b, Proposed Final Environmental Statement, Liquid Metal Fast Breeder Reactor Program: U.S. Atomic Energy Comm. Rept. WASH-1535.

U.S. Bureau of Mines, 1974, Commodity Data Summaries.

U.S. Bureau of Mines, Division of Fossil Fuels-Mineral Supply, 1974, Demonstrated coal reserve base of the United States on January 1, 1974: Mineral Industry Surveys, June 1974, p. 4.

U.S. Coast Guard, 1970, Pollution Incident Reporting System (PIRS) data for 1970.

U.S. Coast Guard, 1972, Marine Transportation System of the Trans-Alaska pipeline system: Study submitted to the U.S. Department of the Interior.

U.S. Coast Guard, 1974, Geographical analysis of oil spill potential associated with Alaskan oil production and transportation systems: Report CG-D-79-74 prepared by Battelle Memorial Institute, Pacific Northwest Laboratories, Richland, Washington.

U.S. Congress, House of Representatives, Committee on Government Operations, 1975, Federal preparedness to deal with the natural gas shortage emergency this coming winter--Third report, together with additional views: U.S. Congress, 94th, 1st sess., House report no. 94-412, 39 p.

U.S. Congress, House of Representatives, Committee on Interior and Insular Affairs, Subcommittee on the Environment, 1974, National energy research--Hearings: U.S. Congress, 93d, Sess., Serial no. 93-19, 583 p.

U.S. Congress, Senate, Committee on Interior and Insular Affairs, 1974, A national fuels and energy policy study: U.S. Cong., 93d, 2d sess., Senate Comm. Interior and Insular Affairs, Comm. Print, no. 93-40 (92-75), 267 p.

U.S. Department of Agriculture, U.S. Interstate Commerce Commission, U.S. Department of the Interior, 1974, Final Environmental Impact Statement, Proposed development of coal resources in the Eastern Powder River Coal Basin of Wyoming, 2 vol.

U.S. Department of Commerce, 1972, Offshore terminal systems concepts, Vol. 1, Figure 1-32.

U.S. Department of Commerce, Maritime Administration, Office of Commercial Development, 1975, Arctic Submarine Transportation System--1975: 7 vols. (Study conducted by Newport News Shipbuilding, Westinghouse Electric Corporation (Oceanic Division), Bechtel Inc., and Mobil Shipping and Transportation Co.) Copy on file in U.S. Dept. Commerce Library, Washington, D.C.

U.S. Department of the Interior, 1972, Alternatives to the proposed action, Vol. 5 of Final environmental impact statement--Proposed Trans-Alaska Pipeline: Washington, D.C., U.S. Dept. Interior.

U.S. Department of the Interior, 1973a, Final Environmental Statement for the Geothermal Leasing Program, 4 volumes.

U.S. Department of the Interior, 1973b, Final Environmental Statement for the Prototype Oil Shale Leasing Program, 6 volumes.

U.S. Department of the Interior, 1973c, Final Environmental Statement for OCS Sale No. 32, Vol. 3, p. 270-286.

U.S. Department of the Interior, 1974, Final Environmental Impact Statement--Proposed Deregulation of Natural Gas Prices.

U.S. Department of the Interior, 1975, Final Environmental Impact Statement--Proposed Federal Coal Leasing Program, [408] p.

U.S. Department of the Interior, Bureau of Land Management, 1973, Energy alternatives and their related environmental impact.

U.S. Department of the Interior, Bureau of Land Management, 1975a, Final Environmental Impact Statement--Proposed Increase in Oil and Gas Leasing on the Outer Continental Shelf, 3 volumes.

U.S. Department of the Interior, Bureau of Land Management, 1975b, Final Environmental Impact Statement--Proposed 1975 Outer Continental Shelf Oil and Gas General Lease Sale, Offshore Southern California, OCS Sale no. 35, 3 volumes.

U.S. Department of the Interior, Bureau of Land Management, 1975c, Final Environmental Statement--Proposed 1975 Outer Continental Shelf Oil and Gas General Lease, Offshore Texas, OCS Sale No. 37, Vol. 2.

U.S. Department of the Interior, Office of Coal Research, 1972, Annual Report.

U.S. Department of the Interior, Title III Study Team, 1975, Alaska Natural Gas Transportation Systems--Message from the President of the United States transmitting a Report on Alaska Natural Gas Transportation Systems, pursuant to Public Law 93-153: Washington, D.C., U.S. Dept. Interior.

U.S. Geological Survey, 1960, Coal map of the United States.

U.S. Geological Survey, 1967, Coal Resources of the United States: U.S. Geol. Survey Bull. 1275.

U.S. Geological Survey, 1972, Energy resources of the United States: U.S. Geol. Survey Circ. 650.

U.S. Geological Survey, 1974, Final Environmental Statement--Proposed plan of development, Santa Ynez Unit, Santa Barbara Channel, Off California, FES 74-20, 3 volumes.

U.S. Geological Survey, 1975a, Sediments, structural framework, petroleum potential, environmental conditions, and operational considerations of the Mid-Atlantic area: U.S. Geol. Survey Open-file report 75-61, 143 p.

U.S. Geological Survey, 1975b, Known U.S. uranium reserves won't meet demand: U.S. Geol. Survey News Release, December 19, 1975, 2 p.

University of Hawaii, 1974, Proceedings of a Conference on the Utilization of Volcano Energy.

University of Oklahoma, Science and Public Policy Program, 1975, Energy alternatives--A comparative analysis: Norman, Okla., University of Oklahoma.

Vaeth, J.G., 1974, The dirigible [Letter]: Science, v. 184, no. 4136, May 3, p. 524.

Wade, Nicholas, 1974, Windmills--The resurrection of an ancient energy technology: Science, v. 184, no. 4141, June 7, p. 1055-1058.

Weeks, L.G., 1960, The next hundred years' energy demand and source of supply: Geotimes, v. 5, no. 1, p. 18-21 and 51-55.

White, D.E., 1973, Characteristics of geothermal resources, _in_ Geothermal energy--Resources, production, stimulation: Stanford, Calif., Stanford University Press, p. 69-94.

White, D.E., and Williams, D.L., eds., 1975, Assessment of geothermal resources of the United States--1975: U.S. Geol. Survey Circ. 726, 155 p.

Wigg, E.E., 1974, Methanol as a gasoline extender--A critique: Science, v. 186, no. 4166, November 29, p. 785-790.

Wilson, H.M., 1973, California geothermal hunt heats up: Oil and Gas Journal, v. 72, no. 5, Jan. 29, p. 70-72.

Wilson, Richard, 1973, Natural gas is a beautiful thing?: Science and Public Affairs (Bull. Atomic Scientists), v. 22, no. 7, September, p. 35-40.

Wolf, Martin, 1974, Solar energy utilization by physical methods: Science, v. 184, no. 4134, April 19, p. 382-386.

Yannacone, V.J., Jr., 1974, Energy crisis--Danger and opportunity: St. Paul, New York City, etc., West Publishing Co., 432 p.

Zener, Clarence, and Fetkovich, John, 1975, Foam solar sea power plant: Science, v. 189, no. 4199, July 25, p. 294-295.

8-G. APPENDICES

8-G-1. Appendix I

Abbreviations

The abbreviations used in this Alternatives volume are as follows:

a.c.	alternating current
B	billion
Bcfd	billion cubic feet per day
bpd	barrels per calendar day
Btu	British thermal units
°C	degrees Centigrade
cf	cubic foot (feet)
d	per calendar day
d.c.	direct current
°F	degrees Fahrenheit
h	hour
hp	horsepower
HV	high voltage
KV	kilovolt
KW	kilowatt
kwh	kilowatt hour
LNG	liquified natural gas
M	thousand
MM	million
MW	megawatt
ppm	parts per million
psig	pounds per square inch gauge
SNG	synthetic natural gas
T	trillion
Tcf	Trillion cubic feet per year

8-G-2. Appendix II

Glossary of Resource Terms

Resources - A concentration of naturally occurring solid, liquid, or gaseous materials in or on the earth's crust in such form that economic extraction of a commodity is currently or potentially feasible. Resources include materials that have been identified but cannot now be extracted because of economic or technologic factors, as well as, economic or subeconomic materials that are yet to be discovered.

Reserves - Identified deposits known to be recoverable with current technology under present economic conditions.

Measured Reserves - Identified resources from which an energy commodity can be economically extracted with existing technology, and whose location, quality, and quantity are known from geologic evidence supported by engineering evidence.

Indicated Reserves - Reserves based partly upon specific measurements, samples, or production data, and partly from projection for a reasonable distance on geologic evidence.

Inferred Reserves - Those reserves based upon broad geologic knowledge for which quantitative measurements are not available. Such reserves are those estimated to be recoverable in the future as a result of extensions, revisions of estimates, and deeper drilling in known fields.

Undiscovered Recoverable Resources - Those quantities that may be reasonably expected to exist in favorable geologic settings, but which have not yet been identified by drilling. Exploration will permit the reclassification of such resources to the reserves category.

Proved, probable, and possible reserves are terms that commonly have been used loosely and interchangeably with the terms measured, indicated and inferred.

Remaining recoverable reserves include the total of measured, indicated, inferred and undiscovered recoverable resources.

8-G-3. Appendix III

Conversion Factors

The following factors have been used in making conversions in the various sections of this Alternatives volume:

Energy Source Unit	Energy Equivalents (Btu/unit)	Equivalent of one cubic foot of gas
Gas		
cubic feet	1032	1 cubic foot
Oil		
barrel (bbl.)	5.8×10^6 (crude)	.0001779 bbl. = $\frac{1 \text{ bbl.}}{5620 \text{ cu. ft.}}$
Coal		
ton (short = 2000 lb.)	22×10^6	.0000396 ton = $\frac{0.223}{5620}$
Electricity		
kilowatt hour + (kwh)	3412*	.3024911 kwh = $\frac{1700}{5620}$
kilowatt hour	10,582**	.0975088 kwh = $\frac{548}{5620}$

*To replace fossil fuel in end use.
**To replace fossil fuel as input to electricity generation.

+ One kilowatt (KW) = 1000 watts (w); one kilowatt (KW) per hour = one kilowatt/hour (kwh); 1000 kilowatts = one Megawatt (MW), a measure of power not energy.

An example of the use of these conversions is shown by the following:

Take the 4.5×10^9 cubic feet per day (4.5 Bcfd) of gas produced in 1985 by the Alaska Natural Gas Transportation System:

Then-

4.5×10^9 cfd gas multiplied by 1032 Btu per cu. ft. = 4.644×10^{12} Btud (or expressed another way 4.5 Bcfd x 1032 Btu =4.644 TBtud).

4.644 TBtud divided by 3412 Btu/kwh = 1.361×10^9 kwh/day (or 1.361 Bkwhd).

1.361 Bkwh/day multiplied by 365 days = 496.7 Bkwh per year.

496.7 Bkwh/year multiplied by 3412 Btu/kwh =1695 TBtu/year.

8.2 PIPELINE - LNG TANKER COMBINATION ROUTES

The proposed action provides for the movement of natural gas by pipeline from two sources--the Prudhoe Bay, Alaska field and the Mackenzie River Delta, Canada field to markets in Canada and the conterminous United States. A major alternative to the proposed action is the movement of Prudhoe Bay gas to the conterminous United States via a combination of pipeline and LNG carrier modes. This alternative provides for the movement of gas only from the Prudhoe Bay field and only to markets in the United States.

Natural gas from Prudhoe Bay would be transported via chilled 42-inch pipeline to a gas liquefaction plant and terminal at Gravina Point on Prince William Sound. The gas would then be shipped by cryogenic tanker, as liquid natural gas (LNG), to a receiving terminal and regasification facility at Point Conception, California. The revaporized gas would be returned to a pipeline and transported to existing facilities at Arvin Station and Cajon Junction in California and sent east of the Rocky Mountains through existing facilities that need augmentation to move this Alaskan gas to eastern markets.

Five variations to the Pipeline-LNG Alternative Route have been considered. Three of the variations are in Alaska and two variations are in California. The Alaska variations considered are:

1) Prudhoe Bay to Cook Inlet

2) Prudhoe Bay to Haines

3) Prudhoe Bay to Golovin Bay

The California variations considered are:

1) Oxnard

2) Los Angeles

For the Pipeline-LNG Alternative system and each of the variations, the project description, the existing environment and the impacts are discussed.

In the concluding section of this volume the Pipeline-LNG Alternative system and the five variations are summarized and the environmental impacts of the Pipeline-LNG Alternative and of the route variations are discussed.

Refer to Figure 8.2.1-1 for a display of the relative location of the Pipeline-LNG Alternative system and the five variations.

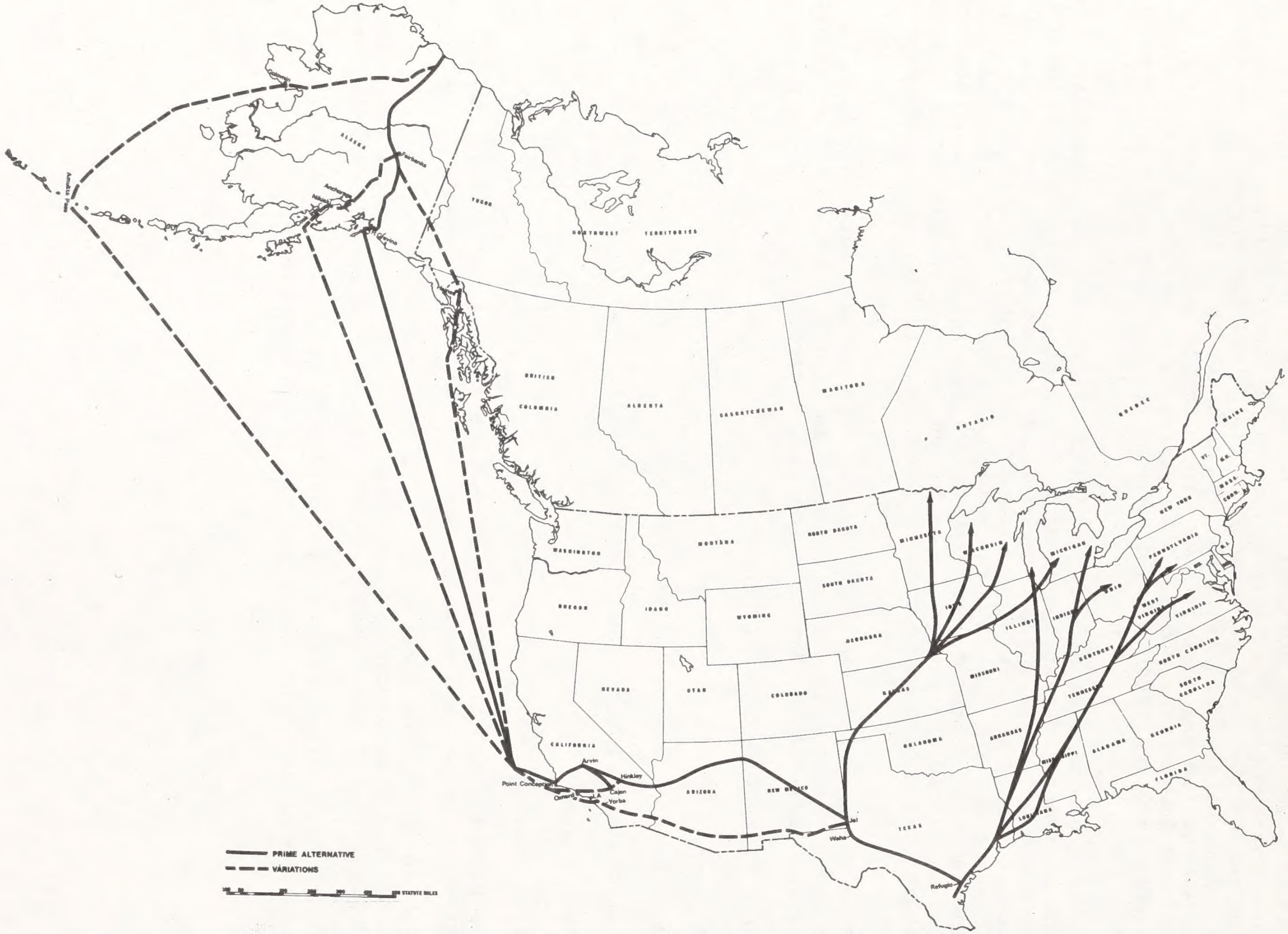


Figure 8.2.1-1. Pipeline - LGN tanker combination routes

8.2.1 Pipeline-LNG Alternative Route: Prudhoe Bay--Gravina Point--Point Conception--Points East

• Introduction

This route is discussed in greater detail than the five variations but the net impact of any of these pipelines would be essentially similar.

The discussion that follows is divided into three parts: Description of the Project; Description of the Environment; and Impact Analysis. Each part is subdivided into three subparts, namely (1) the land route across Alaska and the LNG facilities (see figure 8.2.1-2), (2) transporting of the LNG by ship to the west coast of the United States (see figure 8.2.1-3), and (3) the gasification and transportation of the gas in the lower 48 states (see figure 8.2.1-1).

This system alternative consists of the following components. A 42-inch chilled and buried natural gas pipeline would carry gas from Prudhoe Bay, Alaska, southward approximately 809 miles to Gravina Point on Prince William Sound, Alaska. At Gravina Point the natural gas would be liquefied in an eight-train liquefaction plant. The liquefied natural gas would be loaded into twelve 165,000 cubic meter LNG carriers for shipment to the receiving and regasification facilities to be located at Point Conception, California 1,900 nautical miles to the south. Upon regasification, the gas would be transported 142 miles through a pair of 42-inch pipelines to Arvin, California where a portion of it would be introduced into existing pipelines for distribution eastward. The remaining portion would be transported 105 miles via new pipeline to existing transportation facilities at Cajon, California.

Alaskan gas to the Eastern States would be transported from Arvin by existing pipeline systems utilizing exchange agreements and displacement of gas supplied from gas fields in the Permian and San Juan Basins of New Mexico and west Texas. The portion of Alaskan gas to Cajon Junction from Arvin would go to markets west of the Rocky Mountains.

Description of the Project

The Pipeline From Prudhoe Bay to Gravina Point and the Gravina Point Terminal

This route essentially follows the pipeline corridor delineated for the oil pipeline from Prudhoe Bay to Valdez. The Alyeska oil pipeline route proceeds south from Prudhoe Bay following the Sagavanirktok River to the foothills of the Brooks Range through Atigun Pass then proceeds in a southerly direction toward the Yukon River and then through the interior uplands of Alaska to Fairbanks. From Fairbanks the route goes in a southeasterly direction along the development corridor to Delta Junction, then south along the development corridor through the Gulkana Basin to the Chugach Mountains and Valdez.

The proximity of the gas pipeline route to the oil pipeline route would vary from 300 feet up to 7 miles with several crossovers. Fifteen miles from the end of the Alyeska pipeline, on the Lowe River, the gas pipeline separates from the Alyeska pipeline corridor and travels south 43 miles through the Chugach Mountains to Pt. Gravina.

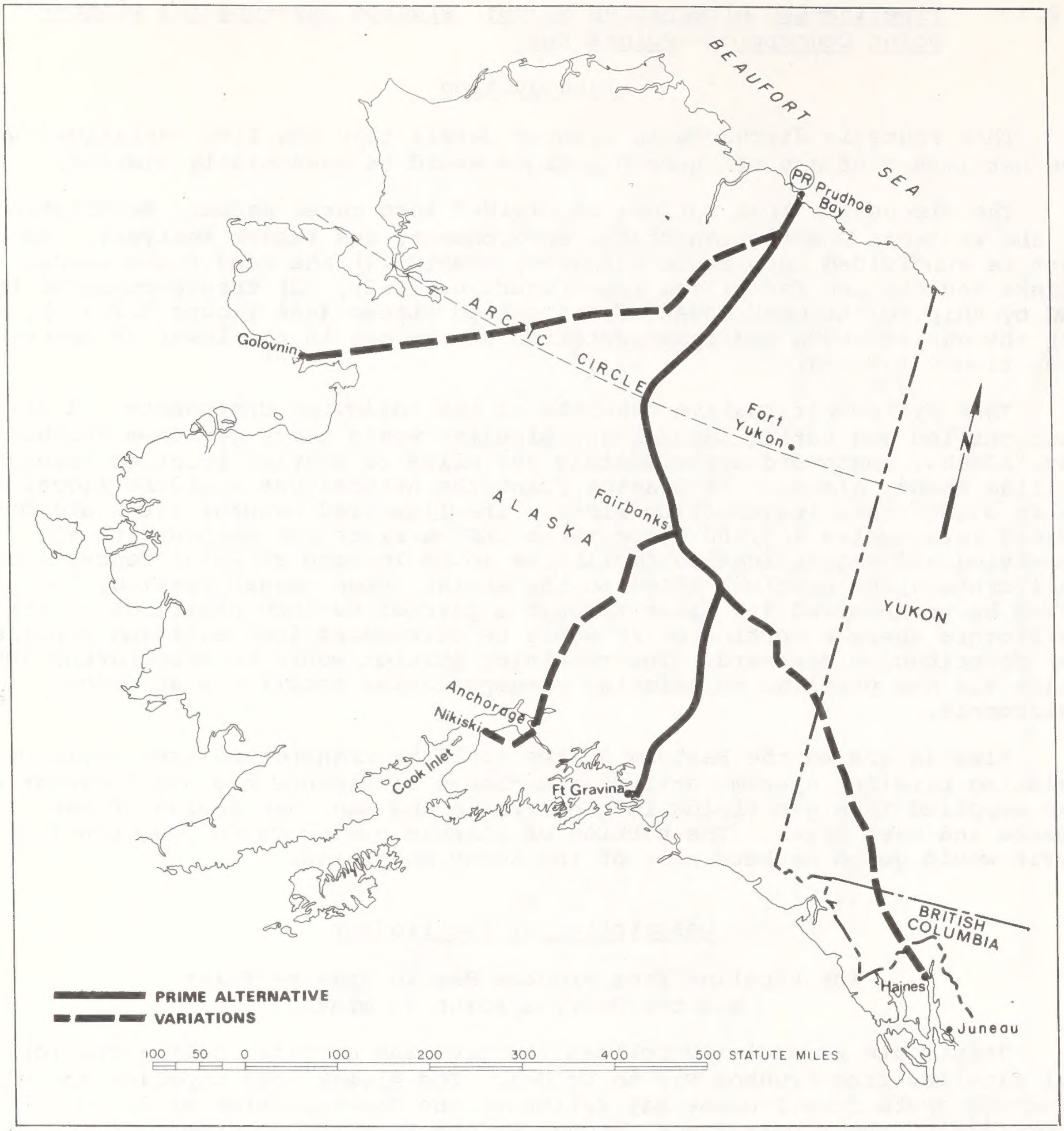


Figure 8.2.1-2 Pipeline routes to proposed LNG terminal sites

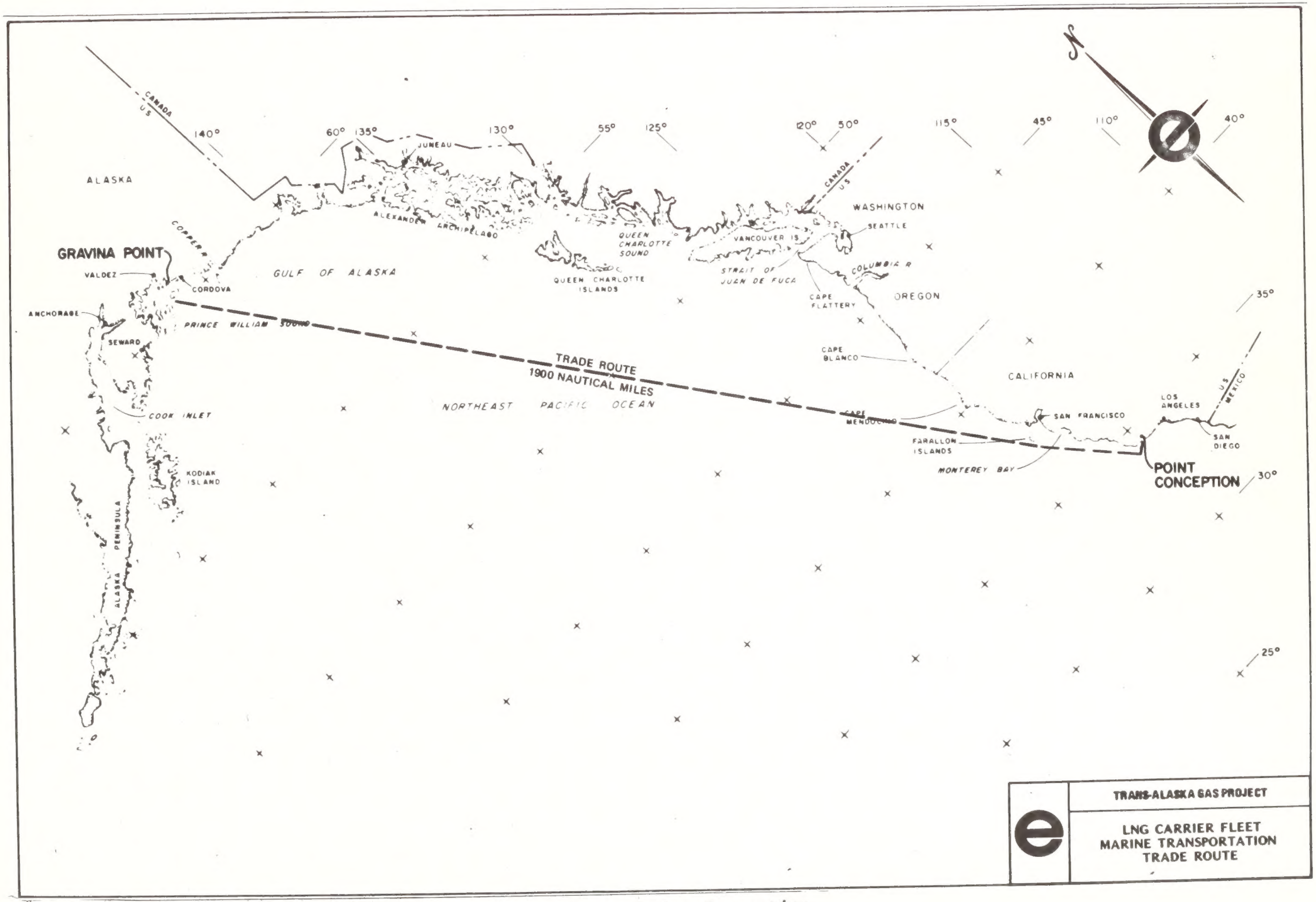


Figure 8.2.1-3 Marine route - Gravina Point to Point Conception

Pipeline Facilities

Related facilities include:

12	compressor stations
11	chillers
27	communication facilities
50	helicopter pads
4	maintenance camps
2	meter stations
No data	permanent storage of spoil from construction of 2 tunnels
4	major pipe storage yards
36	intermediate pipe storage yards
6	construction camps
1	liquefaction plant with storage tanks
1	marine terminal to accommodate simultaneously two LNG carriers
No data	borrow areas for construction materials
1	dispatching and control center
22	miles of permanent road at compressor stations
2	miles of permanent road into pipe storage areas
810	miles of temporary construction road plus unspecified mileages from borrow areas and mileages from borrow areas and material and material storage to right-of-way

The 810 mile long pipeline would be constructed to an ultimate design capacity of 3.364 billion cubic feet of natural gas per day.

The wall thickness of the 42" O.D. pipe would be 0.750 inches. It would have a maximum allowable operating pressure of 1,670 psig. The pipeline ditch would be at least 7 ft. deep and 5.5 ft. wide at the bottom. Burial of the pipe in permafrost areas is intended.

Compressor stations for this alternative would include equipment for compression and refrigeration, buildings to house personnel and generators to provide electrical power for heating, communications, automation and instrumentation. The final station would not require a refrigeration plant.

A total of 12 compressor stations is visualized. Each would be equipped with two 23,400 horsepower gas turbine-driven centrifugal compressor units. A typical emission level would be less than one pound per thousand pounds of fuel used. Peak exhaust stack SO_2 emissions would be below 0.5 ppm.

Gas turbine exhausts, relief valves and vent valves would be designed to restrict noise levels to not more than 90 DBA at a distance of 25 feet from the source.

Valves would be full opening, weld end, 1,800 psig ball valves designed for -50°F operating temperature for above ground facilities and -10°F for buried facilities.

A single Dispatching and Control Center located at Valdez, Gravina Point or Cordova would control the operation of the entire pipeline system.

The gas liquefaction facility and tanker terminal would be located at Gravina Point 36 air miles east of Valdez. It is a remote site with no existing development.

LNG Plant Facilities and Marine Terminal

The process facilities include eight parallel liquefaction trains, each designed to deliver a net equivalent of 378.81 million cubic feet of gas per day to the LNG carrier fleet from LNG storage. Each train is composed of three unit operations: diglycolamine (DGA) gas treating for removal of carbon dioxide, molecular sieve dehydration for removal of water, and refrigeration and compression for liquefaction of LNG.

The LNG product storage and handling facilities would include: (1) four aboveground 550,000-barrel capacity tanks at an operating pressure of 1.6 psig, elevated 150 feet above sea level, and located within a diked area to contain potential spills; (2) LNG pumps to transfer LNG from storage to the LNG carriers; (3) blowers for recovery of vapors from LNG storage, piping, and for vapors generated during ship loading operations; (4) accumulators for collection of LNG from drains and pumps for returning the LNG to storage; and (5) nitrogen surge drum for purging of drained LNG loading arms.

Process support facilities would include electric power generators, an emergency diesel-driven power generator, centrifugal air compressor and desiccant driers, nitrogen gneration facilities, steam generation facilities, waste product and disposal systems, a fire protection system, flares and vents to provide safe disposal of vapors generated during possible emergency conditions, and water systems to provide desalted water, potable water, cooling water, and boiler feedwater.

Various buildings required for plant administration and operation and for operator housing would include: a 30,000-square foot single-story administration building, a 55,000-square foot maintenance shop and warehouse building, an 18,000-square foot control building, a 6,000-square foot fire and safety control building, a 4,500-square foot garage, eight 25,000-square foot compressor buildings, a 5,000-square foot utility building, a 600-square foot DGA sump building, a 1,000-square foot switchgear building, a two-level 60,000-square foot power plant building, a 12,000-square foot recreational building, two 200-square foot shelter buildings, a 7,500-square foot guest house to accommodate 15 people; and 65 permanent homes, each containing 2,500 square feet, in a housing complex to be located three-quarters of a mile west of the proposed plant to provide residences for key operating personnel.

A marine terminal, designed to provide berthing and simultaneous loading facilities for two 165,000-cubic meter LNG vessels, would also be constructed as part of the proposed Pipeline-LNG alternative route project. The primary components of the marine terminal would be one loading platform and one service platform for each of two proposed berths, four berthing dolphins and three mooring dolphins per berth, an additional mooring dolphin common to both berths, personnel bridges, and one trestle which connects the loading and service platforms to shore. Loading arms and a control tower would be located on each LNG platform. Support facilities for the marine terminal would include several buildings located ashore and a small boat harbor which would accommodate tug boats, personnel boats, and a mooring launch.

Operation of the LNG Plant and Marine Terminal

Natural gas from the 818-mile pipeline would enter the property limits of the LNG plant near Gravina Point and pass through a meter station composed of fifteen 20-inch standard orifice meter runs. The feed gas to each liquefaction train would first be processed in a DGA gas treating unit to reduce the carbon dioxide (CO_2) content of the feed gas from 1.02 mole percent to 50 parts per million (ppm) in order to avoid solid CO_2 deposits building up in the LNG tanks and cryogenic exchanges. The gas stream from the DGA gas treating unit would then pass through a molecular sieve dehydration unit to reduce the moisture content of the gas from 0.03 mole percent to less than 1 ppm in order to prevent moisture from freezing and plugging downstream cryogenic equipment. The feed gas would then undergo liquefaction. The eight liquefaction trains would be identical, each having a design capacity of converting 378.81 million cubic feet of natural gas per day into liquid form. The liquefaction process is the Phillips Petroleum Company "Optimized Cascade Cycle". This process utilizes three refrigerants: propane, ethane, and methane. The propane and ethane systems are conventional closed systems with two and three stages of refrigeration, respectively. The methane system would be an open-cycle system utilizing methane-rich gases flashed at four pressure levels from the liquefied natural gas. The process stream would be flashed to remove nitrogen and this flash would provide most of the plant fuel requirements. After a final flash, the LNG would be pumped to storage. The liquefaction process would also include a refrigerant production unit to provide refrigerant make-up for all the liquefaction units. Feed to the refrigerant production units would be taken as a liquid upstream of the methane refrigerant section, and would be demethanized, deethanized, and depropanized, in sequence. The propane would be stored in a conventional 15-foot inner diameter by 100-foot long, horizontal, ambient temperature 2,300-barrel capacity storage tank. The ethane would be stored in a refrigerated 32-foot spherical, 3,000-barrel capacity storage tank designed for -80°F and a pressure rating of 85 psig.

A once-through seawater cooling system would be used as the main heat exchange system in the eight liquefaction units, as well as in the DGA treating and utility coolers and condensers. An air cooling system would also be incorporated into the design. The major sea cooling water users would be the propane condensers and the stream condensers for the methane and ethane compressor turbines. The total seawater system, including the brine discharged from the desalination units, would be designed to return this water to Orca Bay at a flow rate of 658,670 gallons per minute (gpm) and a temperature rise of 20.7°F.

Desalinated seawater would be used to meet the freshwater requirements of the plant, estimated to be a maximum of 725 gpm. The desalinated water would be stored in a 43,000-barrel epoxy-lined, cone roof tank and would be pumped to the potable water, fresh cooling water make-up and demineralizer feed water systems. Desalinated water for potable purposes would be pumped through carbon filters and an automatic hypochlorinator to a drinking water surge drum. A closed freshwater cooling system would be required for the lube oil coolers of the propane, ethane and methane compressors and compressor drivers at a design flow rate of 16,200 gpm and a cooling water temperature rise of 20°F. This heated water would be cooled by seawater in the freshwater-seawater exchanger in order to be recycled back into the process system. Freshwater losses would be sent to holding ponds for discharge to Orca Bay and the make-up freshwater would come from the desalinated water supply. Freshwater would be stored in a 5,200-barrel capacity tank. Desalinated water would also be sent to the demineralizer feed water system for plant steam generation. Boiler flowdown, process area and tank farm storm sewer effluent water, fresh cooling water losses, demineralizer backwash and rinse effluent water, and the clorinated effluent from the sanitary treatment unit would be routed to a holding pond prior to discharge to Orca Bay. Effluents containing oil and oil by-products would be treated, and the demineralizer backwash and rinse effluent would be pH-adjusted prior to discharge to the holding pond.

The LNG would be stored in four 550,000-barrel, metal, double wall, suspended deck, aboveground storage tanks each comprised of an inner tank of 9 percent nickel steel which would be subjected to cryogenic temperatures and hydrostatic pressures of the LNG in storage and a vaportight outer tank of aluminum killed carbon steel for containing internal gas pressure as well as for retaining the insulation which surrounds the inner tank. The annulus between the inner and outer tank would be filled with loose perlite insulation material. A fiberglass electric blanket would be installed around the outside of the inner tank to absorb any differential movement between the inner and outer wall, such as those which could be caused by temperature cycles. Between the inner 9 percent nickel steel and outer carbon steel tank bottoms would be load bearing bottom insulation. A ring-walled foundation would be provided for each tank and electric foundation heating systems would be provided to maintain the temperature of the ground above freezing temperature (32°F) in order to prevent frost heaving. Ground temperatures would be continuously monitored in the LNG plant's control room. The inner tank would be covered by a suspended insulative deck with chimneys so that the product vapor pressure can equalize itself across the deck. The LNG in the tank would be stored at a pressure of 1.6 psig.

Five electrical power generators, each rated at 19 megawatts output, would be provided at the plant. One emergency diesel engine-driven power generator with a 600-kilowatt output would also be provided. The emergency power generator would start automatically in the event of a total power failure at the plant and would supply power for emergency lighting, battery changers for instruments, and electric motor-operated shutdown valves.

The LNG plant would consume approximately 190.7 million BTU's per day due to fuel gas requirements and process losses. Fuel gas would be used for the propane and ethane compressor drivers, electric power generator drivers, supplemental firing in the heat recovery boilers, and miscellaneous services. Fuel gas requirements would be produced in the fuel flash drums of the liquefaction train. Pipeline gas would be available as a backup source of fuel gas. Requirements for average operation are summarized in the following table:

Gas Requirements for Average Operations

User	Gas Required (Billion BTU per day)
Propane Compressor Gas Turbine Drivers	64.71
Ethane Compressor Gas Turbine Drivers	73.43
Electric Power Generator Gas Turbine Drivers	18.60
Supplemental Firing (Heat Recovery Boilers)	19.08
Miscellaneous	14.88
Total for the LNG Plant	190.70

The LNG terminal at Gravina would be located in Orca Bay, in water with a depth of 51 feet at mean lower low water (MLLW), 1,200 feet offshore. At this location Orca Bay is approximately 6 miles wide. Waters in the immediate vicinity of the site range from 50 to 300 feet deep.

An associated small boat facility located adjacent to the marine terminal would extend out approximately 600 feet from shore. The water depth at that point would be about 25 feet MLLW. Land requirements for the proposed system are summarized in the following table:

	Temporary Construction (Acres)	Permanent Construction (Acres)
Pipeline ROW (809 miles)	14,712	5,247
12 Compressor Stations	720	216
15 Communication Sites	15	8
50 Helipads	10	10
4 Maintenance Camps	35	26
Tunnel Spoil Storage Site	100	100
Compressor Station Access Roads (22 miles)	133	133
Roads to storage sites and construction camps (2 miles)	12	12
Total	15,737	5,752

Additional land would also be required off the right-of-way on a temporary basis for main distribution points for pipe, double-joint yards at Prudhoe Bay, Fairbanks, Valdez, and Milepost 118; pipe storage yards at 20-mile intervals along the route; and extra work width at major river crossings. These needs are summarized as follows:

		(Acres)
Pipe Yards -	Prudhoe Bay	20
	Fairbanks	50
	Valdez	23
	Milepost 118	20
36 Intermediate Pipe Storage Yards		72
River Crossing Work Areas		36
6 Construction Camps		132
Construction Material site and Access Roads to the site		1,430
Total		1,783

Scheduling

The construction of the pipeline and related facilities for this alternative route would require an estimated 6.5 years to complete. Two years would be required for accumulation of engineering design data, procurement of materials, and preparation for construction. The actual construction work would span 4 years.

Pipe would arrive in Fairbanks in July of the third project year and in Valdez in September of the same year. Double-jointing and hauling of pipe would start as soon as receipt of the pipe begins.

Manpower Requirements

The project would employ a substantial work force over the engineering, purchasing and construction period. The following is a summary of the construction manpower required:

Project Component	Construction Manpower	
	Peak	Average
Pipeline	4,165	1,422
LNG Plant	4,158	1,605
Alaskan Marine Terminal	120	66

Six pipeline construction spreads would be used as follows.

Section No. 1 (Milepost 0 - 127)--From Milepost 0 near Prudhoe Bay to Milepost 137 near Galbraith Lake, the pipeline would have crossed the Arctic Coastal Plain, the northern foothills and entered the Brooks Range. Construction would require 2 winters. The work season would be from October to May, about 132 days. A long period of total darkness and periods of severe cold and high winds would reduce the effective length of a work season.

Pipeyards would be located at Prudhoe Bay and Fairbanks. Pipe could be hauled from either direction over the State highway constructed by Alyeska. It would be hauled south from Prudhoe Bay. Hauling could begin in early September.

Section No. 2 (Milepost 137 - 270)--From Milepost 137 at Galbraith Lake to Mile 270 near Prospect Creek this route crosses the Brooks Range. All of this section except for a short span in Atigun Pass would be constructed during the winter. The winter work season is estimated to be about 130 days covering a period from late October to late May.

Pipe for the portion of this section lying north of Atigun Pass would come by barge to Prudhoe Bay with the pipe for Section No. 1 and would be hauled south by truck. Pipe for the route south of Atigun Pass would be hauled by truck from storage in Fairbanks.

Section No. 3 (Milepost 270 - 413)--From Milepost 270, at Prospect Creek, to Milepost 413 near Wickersham Dome, the pipeline route would cross 143 miles of foothills and rolling hills from the Brooks Range south across the Yukon River to the Fairbanks area. Construction would be done during the winter months. The work season totals approximately 130 days from late October to early April. Pipe for this section would be hauled north from Fairbanks.

Section No. 4 (Milepost 413 - 560)--From Milepost 413, near Wickersham Dome to Milepost 560 near Darling Creek in the northern foothills of the Alaska Range, the pipeline route would cross 147 miles of flat to rolling terrain with intermittent sharp, choppy hills. Construction would be during the winter. The work season totals approximately 110 days from November to March. Pipe would be hauled south from Fairbanks.

Section No. 5 (Milepost 560 - 718)--From Milepost 560, near Darling Creek, to Milepost 718 near Mosquito Creek, the route would pass through the Alaska Range and cross the rolling terrain of the Gulkana Basin. Except for 40 miles of route across the Alaska Range (MP560-600) this section would to be built in the winter. The work season would extend from November to March and would contain 105 days. The pipe would be hauled north from a pipeyard at the end of the section.

Section No. 6 (Milepost 718 - 809)--From Milepost 718, at Mosquito Creek, to Milepost 809 at the LNG Plant, the pipeline route would cross 91 miles of rugged mountains, canyons and mountain valleys in the Chugach Mountains. Construction, except at river crossings, would be done during the summer. Pipe for this section would be hauled north from Valdez.

Site preparation for the initial compressor station would be scheduled for the summer of the third project year. It would consist of clearing, grading and preparation of the gravel pad over the station site. The work would be completed in conjunction with the site preparation work for the camps, maintenance bases and the construction of roads. Site preparation for the remaining 11 compressor stations would take place during the fourth, fifth and sixth project years.

The LNG facility would require seven years to construct.

Special Problems

Construction through the Atigun Pass would be almost exclusively on rock. The most difficult area appears to be on the south side of the pass at about Milepost 163 where a cut, approximately 800 feet long, would have to be provided on a very steep rock slope. Construction in this area would be complicated by the close proximity of the oil pipeline and highway in this narrow working area.

Near Milepost 455.3, this alternative pipeline route would cross the Corps of Engineers' proposed Moose Creek Flood Control Dike. The Corps of Engineers requires that all dike crossings be over and not through the structures. Therefore, it would be necessary to construct ramps on either side of the proposed dam. Heavy wall, concrete-coated pipe would be used for the portion of the line which might be periodically inundated.

The area between Whistler Creek (MP567) and Trims Creek (MP572) is characterized by a steep valley rising directly from a braided glacier fed stream floodplain. Construction in this section could be further complicated by the presence of the Richardson Highway.

Between Milepost 573 and 575, the pipeline route would cross a major fault zone which is seismically active, the Denali Fault; one of the largest known faults in Alaska.

Special construction would be required for the Tazlina River crossing at Milepost 671.4. An assessment has been made that severe streambed degradation would result from a normal crossing. A 650 foot section of suspended pipeline would span this crossing.

In Keystone Canyon (MP760-672) special construction would be required. Two 9 x 9 feet tunnels with a connecting natural bench would be used to minimize rock work and provide the route for the gas pipeline through Keystone Canyon. The first tunnel on the north end of Keystone Canyon would connect the old Richardson Trail, along which the pipeline would approach the Canyon, to the natural bench. The second tunnel would carry the pipeline from the bench to the high ground at the south end of the Canyon.

LNG Transport (Marine Route)

It is not feasible to ship large volumes of natural gas in the gaseous state. In the liquid state the volume is greatly reduced and it does become feasible. Shipping LNG by sea requires special cryogenic tankers.

A fleet of twelve 165,000-cubic meter LNG tankers would deliver LNG from the Gravina Point loading terminal to the Point Conception, California receiving terminal. Approximately 327 deliveries would be made per year, based upon each of eleven ships operating 330 days per year. The 12th tanker is necessary for unscheduled delays, repairs, shutdowns and weather and sea condition delays of the eleven tankers. A typical 165,000-cubic meter LNG tanker would be 1,002 feet in overall length, 150 feet in beam, 101 feet in hull depth, with a displacement of 122,000 long tons, and a loaded draft of 40 feet. Table 8.2.1-1 shows the principal characteristics of a 165,000-cubic meter LNG carrier. It has a general design configuration similar to smaller LNG vessels presently in service or under construction.

It is not known at this time exactly which cargo containment system would be utilized for the proposed tankers. Cargo containment systems for LNG tankers are presently divided into two general categories: (1) "free-standing" self-supported tanks which have sufficient strength when properly mounted in the hull to support their own weight and dynamic forces of the cargo, and (2) "membrane" tanks in which a thin metal barrier supported by insulation contains the liquid that in turn transmits the weight and dynamic forces of the cargo to the inner hull structure of the vessel. Of these systems, five designs are considered acceptable for use in the LNG fleet. These include spherical tank designs by either Kvaerner-Moss or Chicago Bridge and Iron, the Conch free-standing tank, and membrane tank designs by either Gaz Transport or Technigaz. Selection of the shipbuilding yard(s) would depend on the type of design chosen; however, shipbuilding yards such as Avondale Shipyards, Bethlehem Steel, General Dynamics, Ingalls Shipbuilding, Newport News Shipbuilding and Dry Dock Co., or Sun Shipbuilding are also possible candidates for shipbuilding contracts.

The marine transportation route extends from the Alaskan marine terminal to Point Conception, approximately 120 miles north of Los Angeles (see Figure 8.2.1-3). The 1,902-nautical mile voyage would require approximately 4 1/2 days at an average speed of 18.5 knots. After departing from the terminal waters of Orca Bay, an outbound LNG carrier would traverse the western extremity of the bay for approximately 10 nautical miles to Prince William Sound proper. The western side of Hinchinbrook Entrance would be the outbound ship traffic lane. The corresponding traffic inbound lane would be east of the outbound lane. Outbound vessels would then transit the Gulf of Alaska and northeast Pacific Ocean. Transit of waters off California would be west of the Farallon Islands, which are located approximately 25 nautical miles west of San Francisco, to avoid coastal traffic. The approach to the proposed Point Conception terminal would begin south of Point Arguello and once clear of Point Conception and Government Point the vessels would make a direct transit to the proposed terminal site. The vessels would contain a rudder system with a rudder angle of 45° to decrease the turning radius and a 2,500-hp bow thruster system to aid in slow speed manuevering and to assist docking tugs used at the marine terminals. An LNG tanker would be berthed by two large tugs, with assistance from the bow thruster and when necessary, a soft rope first line ashore system. See table 8.2.1-2 for the Cost Estimate Summary.

The Point Conception Terminal And The Pipeline From Point Conception To Cajon and Arvin California

The Point Conception terminal regasification facility would be located on the Southern California coastline 4 miles east of Point Conception.

The pipeline would consist of two 42-inch underground, parallel pipelines with a total length of 142.3 miles which would deliver a peak volume of 3.1 billion cubic feet per day to existing facilities at Arvin near Bakersfield, California. A single 42-inch pipeline would continue from there to Cajon Junction, 105 miles to the southeast.

Table 8.2.1-1 LNG carrier fleet, principal characteristics of a 165,000 m^3 LNG carrier

LNG Capacity, 100% Cold	165,000 m^3
Length Overall	1,002 feet
Length Between Perpendiculars	952 feet
Beam	150 feet
Depth of Hull	101 feet
Design Draft	40 feet
Displacement	122,000 Long Tons
Block Coefficient	0.75
Propulsion Horsepower	55,000 HP
Number of Propellers	2
Type Propulsion	Geared Steam Turbine
Trial Speed (at 90% HP)	19.75 Knots
Service Speed (at 90% HP)	18.50 Knots
Ballast Capacity, 100%	66,000 Long Tons
Fuel Oil Capacity, 100%	8,200 Long Tons
Bow Thruster Horsepower	2,500 HP
Number of Cargo Tanks	5
Cargo Pump Capacity	14,000 m^3/hour
Cargo Boiloff	0.15% Cargo Volume/day
Number of Manifold Lines	5 Lines, 16-inch Diameter Each
Crew	11 Officers, 24 Crewmwn

Source: Federal Power Commission, 1975, Vol. II

Table 8.2.1-2 Cost estimate summary

Description	Cost (in millions)	
Alaskan Gas Pipeline	1,351.4	
LNG Plant	1,176.1	
Marine Terminal	30.3	
LNG Carrier Fleet	1,590.5	
Total Direct Cost		4,148.3
Add: General Overhead	52.5	
Contingency	129.5	
Contract Project Management Fee	61.6	
Intangible Plant	15.9	
Allowance for Funds Used During Construction	1,477.9	
Line Pack	2.9	
	(303.1)	
Start Up Costs		1,437.2
Total Project Cost		5,585.5

Facilities

The facilities at Point Conception, California, would be designed to receive LNG transported by ship, unload and transfer it into insulated storage tanks, and withdraw and vaporize it for delivery into gas transmission pipelines. The plant would be capable of handling 4 billion cubic feet per day (4,000 MMcfd) of natural gas, with a peaking capacity of an additional 1,000 MMcfd.

Access to the site would be via a two-lane, paved road which roughly parallels the coastline and railroad tracks. It connects with Highway 101 approximately 12 miles to the east.

The marine berthing and unloading facilities would be about 4,600 feet offshore in 60 feet of water (MLLW). They would accommodate and unload simultaneously 2 LNG ships of up to 165,000 cubic meters capacity.

The berthing facilities would have a "T"-head configuration, the stem of the "T" being a trestle approximately 4,600 feet long. This trestle would run to shore from an operating platform which is located at the intersection of the stem and the head of the "T." Trestles would also run from the operating platform to each berth. Each berth would consist of an unloading platform, a service platform, breasting dolphins, and fixed mooring dolphins. The trestle would carry a concrete roadway and piping.

The deck structure for all platforms would be concrete construction supported on precast, prestressed concrete piles. The deck elevation would be 40 feet above mean sea level (MSL), to place it well above the crest height of the maximum expected wave. The main deck would support the piping, valves, manifolds, equipment, and controls required for unloading operations. In addition, there would be a secondary platform supporting five 16-inch unloading arms (4 LNG lines and 1 vapor return line) and an arm for loading bunker fuel oil. There would be a control tower to provide an unobstructed view of the unloading operation.

The service platform would consist of a concrete deck at elevation 40 (MSL). This platform would be equipped with a crane to load stores aboard ship. An access gangway attached to the platform would provide personnel with access to the vessel.

Mooring dolphins would have quick release hooks and capstans on a mass concrete cap supported on steel pipe piles. The breasting dolphins would be of the flexible type and would consist of large-diameter, high-strength, steel-pipe piles.

All steel piles would have a corrosion-resistant protective coating plus cathodic protection to inhibit corrosion.

A small boat harbor would be constructed adjacent to the access trestle approximately 3,000 feet from shore in 20 feet of water (MLLW). During site construction, the harbor would be used as a construction dock; during plant operation, it would be used as a shelter for tugs, barges, and other small craft. It would consist of a rock breakwater which would be connected to the trestle via a roadway on the top. Pumps for offloading bunker and fuel oil would also be located here.

A cryogenic LNG transfer system would be required to carry the LNG from the ships to the storage tanks. This system would consist of two 36-to 42-inch-diameter insulated cryogenic lines and one 18-inch vapor return line. It would be approximately 6,000 feet long, 4,600 feet of which would be mounted on a trestle; 1,400 feet would be installed above ground on the plant site.

Four LNG storage tanks of 550,000 barrels each would be required at the site. Each tank would have the following approximate dimensions:

Diameter	240 feet
Shell height	80 feet
Overall height	129 feet

Each tank would be surrounded by an earthen berm 10 feet high with sufficient volume within the berm area to contain the full contents of the storage tank.

The vaporization plant would consist of vaporizers, an odorizing and metering system, and required peripheral equipment. It would be situated adjacent to the LNG storage tanks. Base load vaporizers would be used to vaporize the LNG. These vaporizers would utilize seawater in the warming process and then return the cooled seawater to the ocean.

Gas-fired trim heaters would be used to raise the gas temperature from 40°F to 50°F prior to delivery to the gas transmission system. Ten submerged-combustion gas-fired vaporizers would provide a peaking capacity of up to 1,000 MMcfd for use during periods when normal base load operations could not meet load requirements and when seawater vaporizers require maintenance.

Four 10-foot-diameter seawater exchange lines would be required for the seawater vaporization system. Two of these lines would connect the plant with the adjacent seawater intake; the other 2 would return the water to the ocean.

The terminal's daily electrical power requirements would be 40,900 kilowatt (kw) peak and 39,100 kw average and would be purchased from Southern California Edison Company. Existing generating capacity is sufficient to provide the power requirements, however, the Goleta California Transmission substation would require enlargement. The terminal would have two standby diesel-driven generators, one 300 kw and one 600 kw, to supply emergency electrical power for lighting and control systems.

An onsite seawater desalination plant would supply fresh water for domestic and sanitary use at the rate of 42,100 gallons per day (gpd). At full operation, the facility would produce 4,000 gpd of sewage which would be treated in an activated sludge unit and chlorinated for disinfection. Wastewater from the desalination unit boiler blowdown (0.5 gpm), from the gas-fired vaporizers (70 gpm maximum), storm drain runoff, and treated sewage (7 gpm) would be combined and retained in a holding pond prior to discharge into the ocean.

A new pipeline system would be required to transport the natural gas from the Point Conception regasification facility to existing transmission facilities.

Parallel 42-inch diameter pipelines with a maximum allowable operating pressure of 1,440 psig would be constructed between Point Conception and Arvin. No compressor station would be necessary.

The pipeline to Arvin would begin at the Point Conception terminal and proceed easterly, parallel to the coast. After 5 miles, the line would turn north and pass through the Santa Ynez Mountains, crossing the Santa Ynez River at milepost (MP) 14.5. The pipeline would proceed through Drum Canyon and the Purisima Hills to a crossing of U.S. Highway 101 and the San Antonio

Land Requirements

Permanent Requirements	Acres
Regasification Facility	227
Marine Terminal (Berthing and Unloading)	31
Point Conception to Arvin Pipeline	1,300
Arvin to Cajon Junction	660
Total	2,218

Temporary Requirements	
Point Conception (Construction Yard)	1,000
Arvin to Cajon Junction	660
Total	1,660

Length of Pipelines

	Miles
Point Conception to Arvin	142
Point Conception to Cajon Junction	242

(Dual 42-inch pipelines are planned for 133 miles with a total permanent and temporary land requirement of 125 ft. width of R/W.)

Creek at MP 25. At MP 34, the pipeline would cross the Sisquoi River and continue through the San Rafael Mountains, the Los Padres National Forest, and the Sierra Madre Mountains. The pipeline would cross the Cuyama River and State Highway 166 at MP 55.5, turn easterly at MP 65, and follow the Carrizo Plain. The pipeline would then cross the San Andreas fault zone at MP 86, climb the Temblor Range, and enter the San Joaquin Valley. At MP 135, after crossing the California Aqueduct and U.S. Interstate Highways 5 and 99, the route would proceed north and terminate at MP 142.3, the site of a proposed metering station adjacent to existing facilities near Arvin, California.

A meter station capable of measuring the total gas to be delivered would be located at the outlet of the pipeline. The location would be at or near the point of connection to the receiving pipeline at Arvin.

The pipeline to Cajon would connect with the Point Conception to Arvin pipeline at MP 133, about 9 miles south of the Arvin pressure limiting station, and proceed easterly across the San Joaquin Valley. After crossing Tejon Creek at MP 4.1 and Chanac Creek at MP 8.4, the line would ascend the western foothills of the Tehachapi Mountains and pass through Cummings Valley. At MP 17.6, the pipeline would again cross Chanac Creek and pass through Tehachapi Valley, crossing six intermittent creeks. The pipeline would enter the upper alluvial slopes of the Mojave Desert at MP 30, cross the Los Angeles Aqueduct at MP 34.3, and turn southeasterly at MP 40. Continuing through the Mojave Desert, the pipeline would traverse Edwards Air Force Base property from MP 48.6 to MP 68, and head due south at MP 90.1. The pipeline would connect with the Adelanto pressure regulating station at MP 93.1 and cross the California Aqueduct at MP 100, the Southern Pacific Railroad at MP 103.1, and Interstate highway 15 at 107.6. The line would terminate at a metering station in Cajon, California at MP 108.9.

Regulating valves would be installed at Arvin and the terminus of this portion of the gas transmission pipeline for flow control and to protect the existing gas transmission pipeline against overpressurization. Pressure monitoring valves and control would also be provided. All valves would be buried to minimize noise.

Telemetric equipment would be installed at the metering station to send flow rate measurement data to the Point Conception Control Center. The Point Conception Control Center would also remotely control the metering station.

Scheduling

The overall construction period for the Point Conception plant facilities would be about 39 months. The total time required to construct the pipeline, including ground survey, construction, and hydrostatic testing of the facilities, is less than 26 months. The completion of these facilities would be coordinated with the completion of the overall project.

Manpower Requirements

A labor force ranging from 300 to 1,810 workers would be employed in the construction of the marine terminal and LNG facility. The company's schedule shows a span of employment of 13 quarters (39 months) with near peak employment during quarters 6-9.

The work force that would be employed in constructing the pipeline as far as Arvin would average 926 persons. No data are available on the size of the work force required for the segment between Arvin and Cajon Junction.

Arvin, California to Eastern United States

This segment of the alternative would transport 1.5 billion cu. ft./day of regasified LNG Alaskan gas from Point Conception to eastern markets through existing pipeline systems beginning at Arvin. This would be half of the peak day volume of the regasification plant at Point Conception. The other 1.5 billion cu. ft./day would be destined for customers in areas west of the Rockies and would also be transported through existing pipeline systems. New construction and/or modifications required to increase the capability of these existing systems to transport the Alaskan gas would be:

- 12 new compressor stations
- 24 pipe and other modifications to existing compressor stations
- 418.5 miles of 42" O.D. pipeline
- 9.5 miles of 30" O.D. pipeline
- 13.0 miles of 24" O.D. pipeline
- 109.7 miles of 20" O.D. pipeline
- 1.1 miles of 16" O.D. pipeline

Pipeline segments in certain areas would be tested for qualifications at the required higher operating pressures and, where necessary, replaced. Estimated Land Requirements for this segment of the alternative are:

Temporary Acreage Requirements

Construction Rights of Way, yards, etc.	3000 Acres

Permanent Acreage Requirements

Pipeline Row	2800
Compressor Stations	200
Total Permanent Acres	3100

The plan would be based on the following assumptions:

1) The regasification plant would be set at its maximum rate of 3.1 billion cu. ft. per day.

2) Gas supplies presently produced at two gas fields, the Permian Basin in west Texas, and the San Juan Basin in north western New Mexico, would be set at a minimum rate of flow. This would minimize the quantity of gas displaced and maximize the amount of Alaskan gas to be transported east.

3) Minimum sales to California would be used.

4) The abandonment of a 30" OD gas pipeline that serves California from the Southeast corner of New Mexico.

5) The pipeline system of another company (Transwestern Pipeline Co.) would be utilized in the eastern movement and displacement of Alaskan gas from the California-Arizona border. (Alaskan Gas would be delivered from Arvin to the California-Arizona Border by existing lines belonging to Pacific Gas and Electric and Southern California Gas Corp.)

The plan would include the capability to deliver an added 775 million cu. ft. per day. This additional flow is an apportionment of the approximately 17.9% of Alaskan gas for which no dedication has been indicated. The total design day delivery, at 1050 Btu/cu. ft., less fuel usage and other losses, would be 2.275 billion cu. ft. by the combination of two existing pipeline systems. Of this amount, 1.201 billion cu. ft. per day would be delivered directly to the Permian Basin and Panhandle areas in Texas. 1.074 billion cu. ft. per day would have to be transported to the Gulf Coast for delivery near Refugio, Texas.

The design would permit the flow in the two systems to be reversed to a westerly direction, if necessary, to offset the effects of an unexpected interruption of Alaskan gas to the west coast.

Both Transwestern Pipeline Co. and El Paso Natural Gas Company have trunklines between the Permian and Panhandle areas. Transwestern, with installation of the necessary compression, would have a northeastward flowing capability into the Panhandle of 370 million cu. ft. per day. This would require the construction of a new 9840 horsepower compression station near Franconia, Arizona. Additionally, Transwestern purchases gas in the Panhandle and has a delivery commitment in the Panhandle of Texas of approximately 25% of their system supply. For the Alaskan delivery system, 40 million cubic feet per day would be transferred to El Paso Natural from Transwestern through a new interconnection into El Paso Natural's Dumas-Schafer line near the Schafer Plant in the Panhandle where Transwestern and El Paso Natural presently cross. New construction for this operation would consist of two compressor stations of 2136 horsepower each.

El Paso Natural presently has a northward flowing capability of approximately 300 million cubic feet per day into the Panhandle; however, they would complete the looping of their line between the Permian and

Panhandle by constructing approximately 107 miles of 20 inch pipeline paralleling an existing 24-inch line between Dimmit and Dumas at the north end of that system. Construction of one new 9600 hp compressor station at Littlefield in addition to existing compressors would increase compression capability to 22,720 horsepower, and would give El Paso Natural a flowing capability of 490 million cu. ft. per day in addition to the supply they purchase in the Panhandle.

The 214 million cu. ft. per day volumes committed to the Natural Gas Pipeline Co. system could be delivered directly at a combination of two delivery points. A new interconnection for 100 million cu. ft./day would be constructed near Tatum, New Mexico at the point where the existing El Paso Natural system crosses Natural Gas Pipelines truckline between the Permian and Panhandle areas. New construction would consist of a new 1068 hp compressor station. The remaining volume of 114 million cu. ft. per day would be delivered to Natural Gas Pipeline at their station 112 in Southeast corner of Moore County Texas in the Panhandle. New construction would consist of one mile of 16" OD pipe.

Deliveries to Northern Natural Gas Company of 548 million cu. ft/day would be accomplished by combining two deliveries. The first is at an existing delivery point from El Paso Natural to Northern Natural by displacement of gas otherwise flowing from Northern Natural to El Paso Natural at Plains, Texas. At the present time, El Paso Natural has a transportation contract under which it is obligated to transport up to 575 million cu. ft./day for Northern Natural from Plains to Dumas, Texas. Deliveries of Alaskan gas to Northern Natural could be made at Plains by displacement of gas that would otherwise be received for transportation from Northern Natural.

Panhandle Eastern Pipeline Company's entire 172 million cu. ft/day of Alaskan gas would be delivered directly to Panhandle Eastern at their Sneed Station near the Moore/Hutchinson County line in the Panhandle. This delivery could be made from El Paso Natural's existing Dumas to Schafer Pipeline. New construction for this operation would consist of three miles of 20" OD. pipeline.

Michigan Wisconsin Pipeline Company would receive their apportionment of the Alaskan gas (267 million cu. ft./day.) by direct delivery from Transwestern 24-inch line north of Pampa, Texas, where Transwestern presently crosses Michigan Wisconsin's 20-inch line running from Gageby Creek to the E.G. Hill compressor station.

This pattern of distribution utilizes most of the existing northward flowing capability of the four systems presently interconnecting the Permian and Panhandle areas. The projected aggregate unused capability for these systems for northward flow in the year 1984 would be 81 million cu. ft./day.

Three of these systems - Natural Gas Pipeline, Northern Natural, and Panhandle Eastern appear to have adequate capability to move gas northward in their trunklines from their receiving points in the Panhandle. The Michigan Wisconsin system would probably require an additional 4,000 horsepower compressor at their Meade Station, the construction of a new 3,200 horsepower intermediate station between the Transwestern delivery point and their E.G. Hill Station, and a 1,500 horsepower booster for the Gageby Creek Flow, located either at the Transwestern delivery point or in the field. Transwestern would require two new compressor stations totalling 13,120 horsepower on their mainline between Roswell and the Panhandle.

Deliveries to the Gulf Coast would require the construction of 418.5 miles of 42" O.D. pipeline and 13 miles of 24" O.D. pipeline extending from

Waha, Texas to Refugio. Two mainline compressor stations of 20,800 horsepower each would also be required. The pipeline would have the capability of moving 1.074 billion cu. ft. to four major existing pipeline systems belonging to Texas Eastern Transmission Corporation, Transcontinental Gas Pipeline Corporation, and Natural Gas Pipeline Corporation of America. Another customer, Columbia Gas, has no system into South Texas and would have to utilize other companies' pipelines. The Columbia apportionment of 595 million cu. ft./day is larger than can be transported by any single line, so it would be split equally between Tennessee and Natural Gas Pipeline. Each of these two systems could have adequate capacity from Refugio into their trunklines emanating from the Louisiana area. Also, they could readily return Columbia's volumes at points in South Louisiana where each company has major lines intersecting Columbia trunklines.

It appears at this time that no significant construction requirements or unusual exchange arrangements would be necessary for the Alaskan Gas to be moved from Refugio into the trunklines of any shippers, nor for them to move the gas to their markets.

Description of the Existing Environment

The Pipeline From Prudhoe Bay to Gravina Point and the Gravina Point Terminal

The route of this alternative system follows the Alyeska pipeline right-of-way within the BLM corridor from Prudhoe Bay to near Valdez. This environment has already been altered by the work now being done on that pipeline.

Climate

This alternative route crosses the Arctic, Continental and Transition Climate Zones (Figures 8.2.1-4a and 4b). In addition, the Maritime Zone is encountered in Prince William Sound.

Temperature--Temperature data are becoming available for this route. There are some major reporting stations along the route and the data they accumulate are now being augmented by observations at Alyeska camps. Figures 8.2.1-5a and 5b and 8.2.1-6a and 6b display, respectively, the January minimum and July maximum termperatures along the route.

In the Arctic Zone north of the Brooks Range, temperatures range between 40 and 75°F during the summer months and between -20° to -60°F in winter.

In the Continental Zone directly south of the Brooks Range, the summer temperatures probably range from the upper 60's to the upper 70's but during winter drop to -5 to -25°F. Extremes range from about 100°F in the area south of the Brooks Range to lows of from -60 to -75°F in both areas.

On the basis of partial years' records from Arctic Village, a monthly average of -36°F is recorded for January and a monthly average of 54.9°F is recorded for June.

The mean annual temperature in the Transition Zone approaches 32°F. In the Maritime Zone the mean annual temperature is about 39°F.

Precipitation--Precipitation in the Arctic Zone ranges from 4 to 10 inches per year along the sea coast to about 40 inches per year in the Brooks Range. It drops again to less than 10 inches per year in the lowlands south of the Brooks Range. Based upon partial years' records at Arctic Village, the months of heaviest precipitation are in the summer, although the existing records indicate fairly uniform distribution throughout the year.

Average precipitation in the Continental Climatic Zone ranges from 8 to 24 inches. Fairbanks, for instance, has a mean annual rate of 11-26 inches.

Precipitation in the Transition Zone ranges from 12 inches in the north to 60 inches in the south. The average annual precipitation in the Maritime Zone is 40 inches with a range of 11 to 150 inches per year.

Refer to Figures 8.2.1-7a and 7b for the mean annual precipitation rates along this alternative route.

Winds--Prevailing winds in the area north of the Brooks Range are generally northerly in winter and southerly in summer.

South of the range, direction is variable with little seasonal pattern. Wind speeds generally range from about 3 to 7 miles per hour, although winds of 50 miles per hour have been noted. In the Brooks Range passes, even higher wind speeds could occur.

No data are available from the Arctic Village area for wind velocities and direction. Data at other Interior stations, further removed from the route, indicate that wind speeds are generally lowest during winter and highest during summer.

From Delta Junction southward winds seldom exceed 10 mph except for occasional localized conditions, often topographically influenced. Winds normally range from 3 to 7 mph along the route in this area.

Destructive Storms--No specific data are available on destructive storms anywhere along the route. On the coast of the Arctic Ocean, periodic onshore winds of high velocity drive water over the low banks and cause flooding. High winds cause damage throughout the entire area.

Micrometeorological Conditions--Ice fog, is particularly severe in the Fairbanks environs. This phenomenon is related to any moisture source introduced into a cold atmosphere. It is probable that any village or camp along this alternative route could generate locally severe ice fog conditions.

Air inversion is known to contribute to air quality and will be discussed under Air Quality later in this section.

Topography

This alternative crosses 13 physiographic provinces. These, shown on Figures 8.2.1-8a and 8b, are as follows:

Arctic Coastal Plain--The Arctic Coastal Plain is a smooth plain rising imperceptibly from the Arctic Ocean to a maximum altitude of 600 feet at its

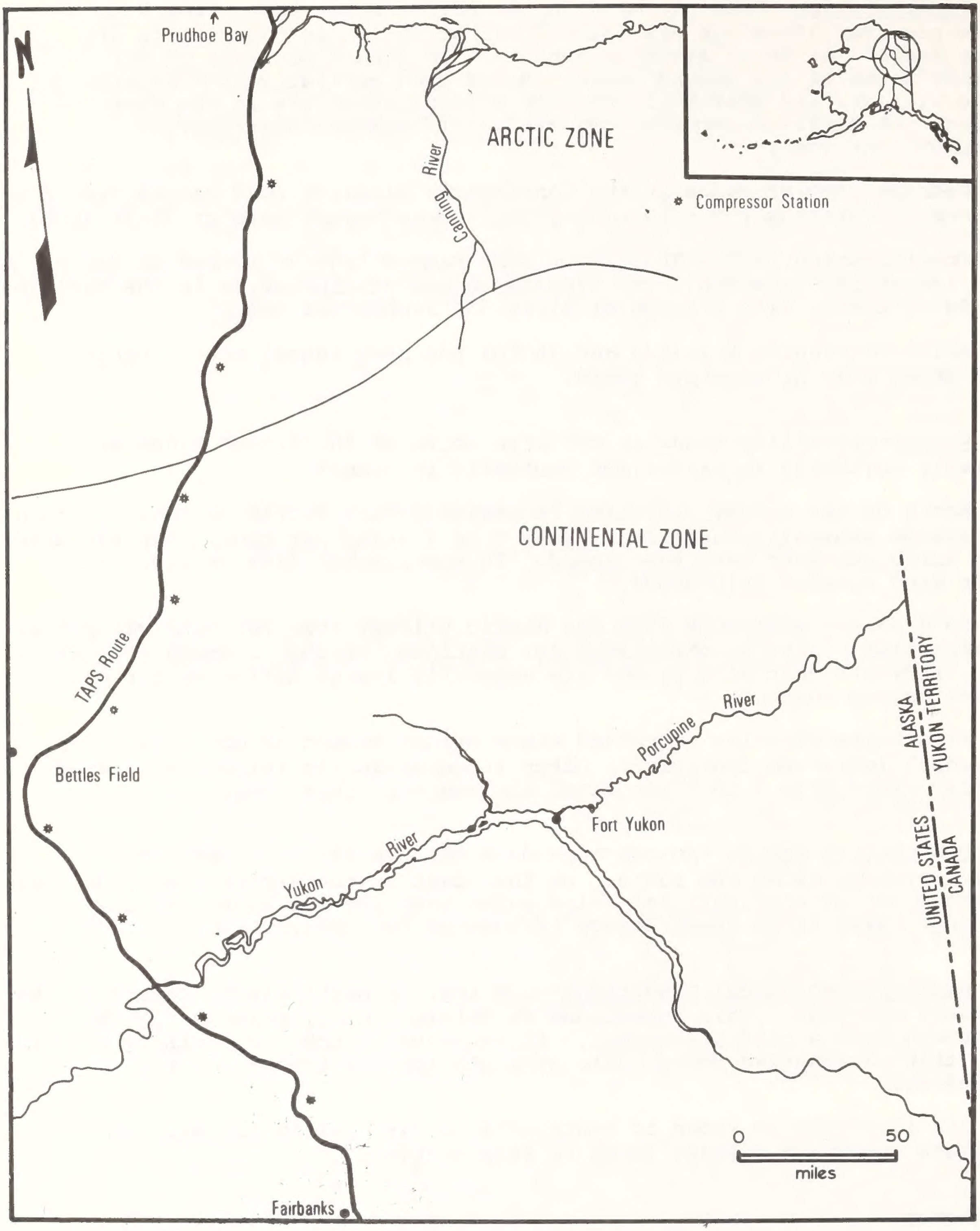


Figure 8.2.1-4a Climate - climatic zones

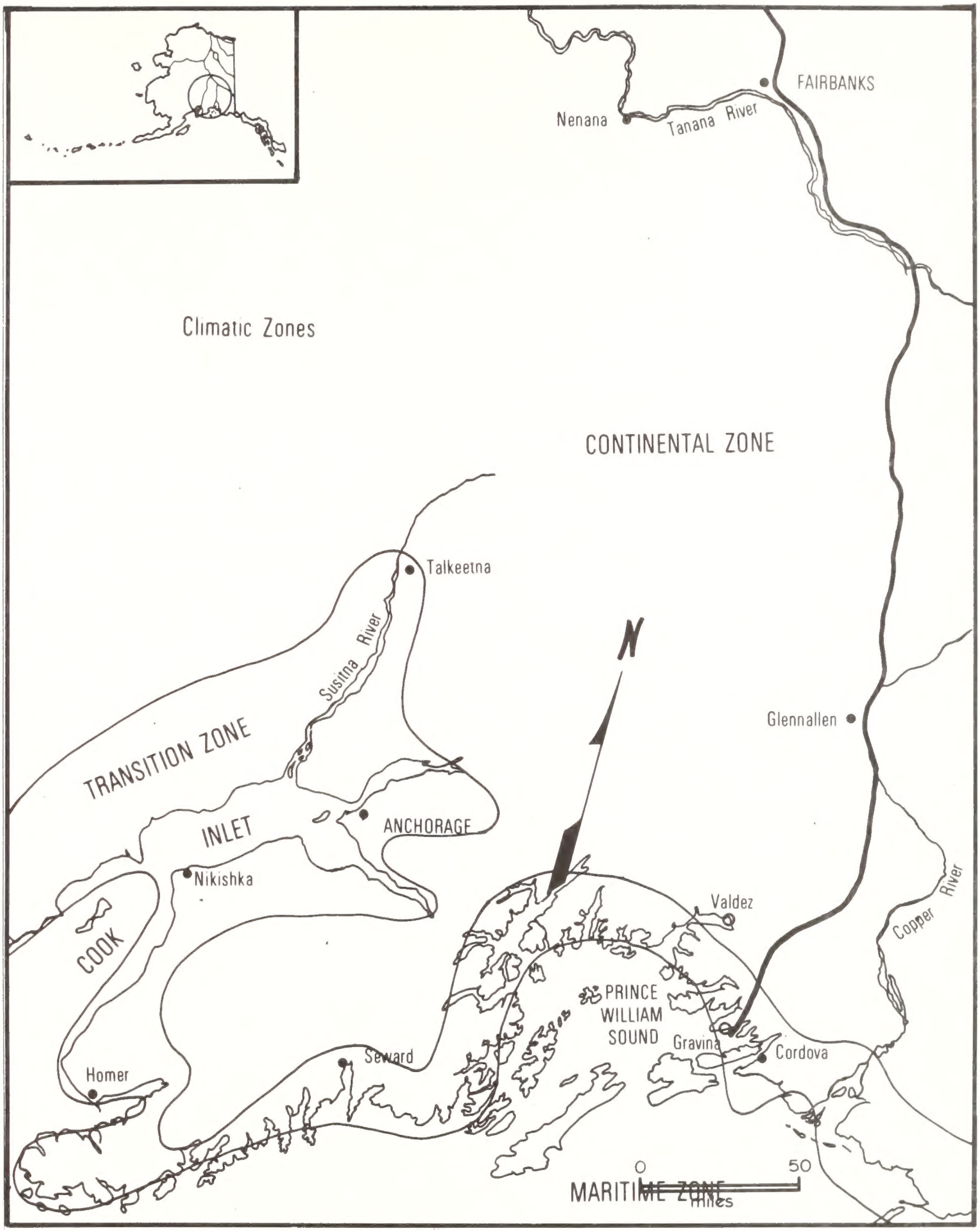


Figure 8.2.1-4b Climate - climatic zones

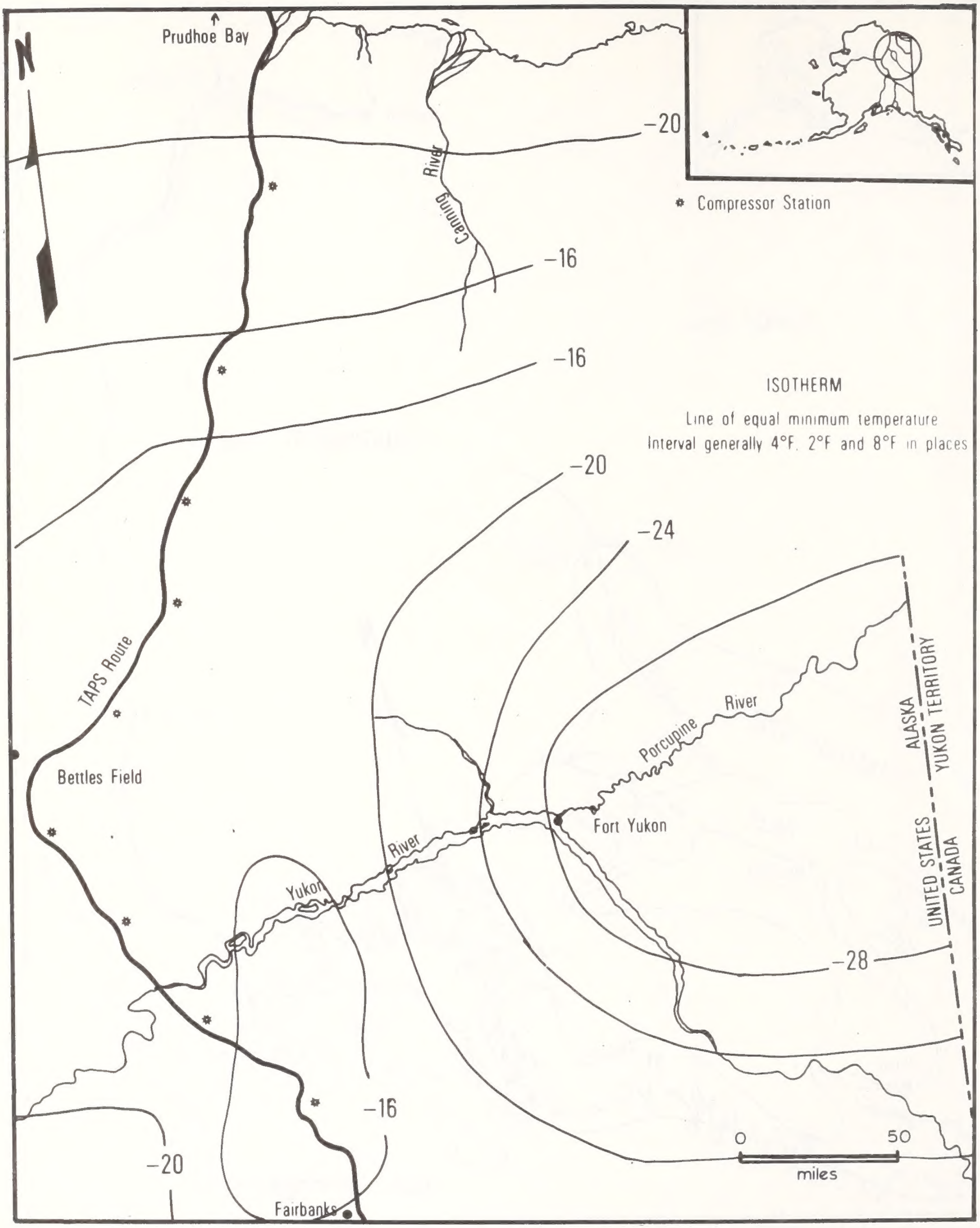


Figure 8.2.1-5a Climate - mean January minimum temperatures °F

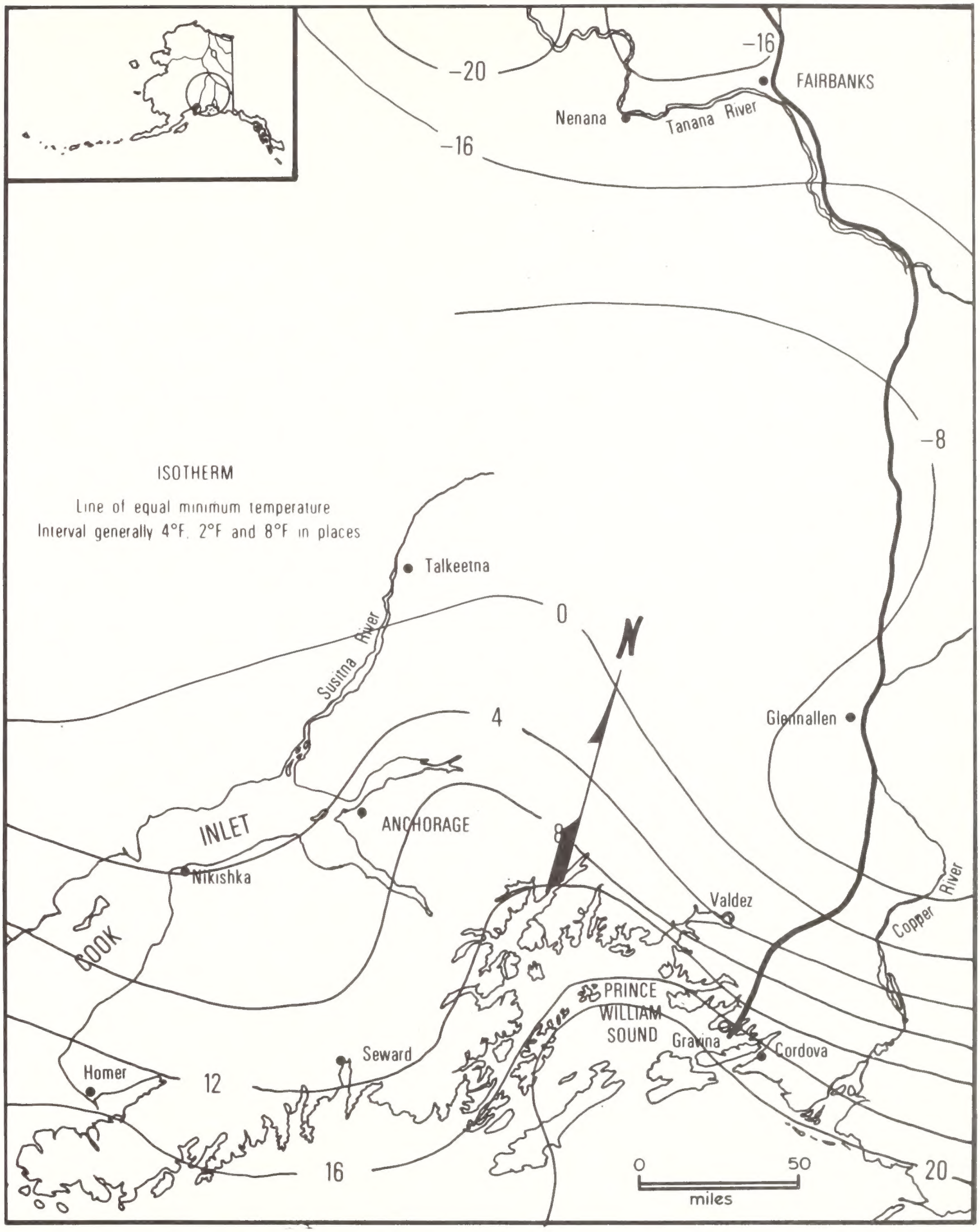


Figure 8.2.1-5b Climate - mean January minimum temperatures °F

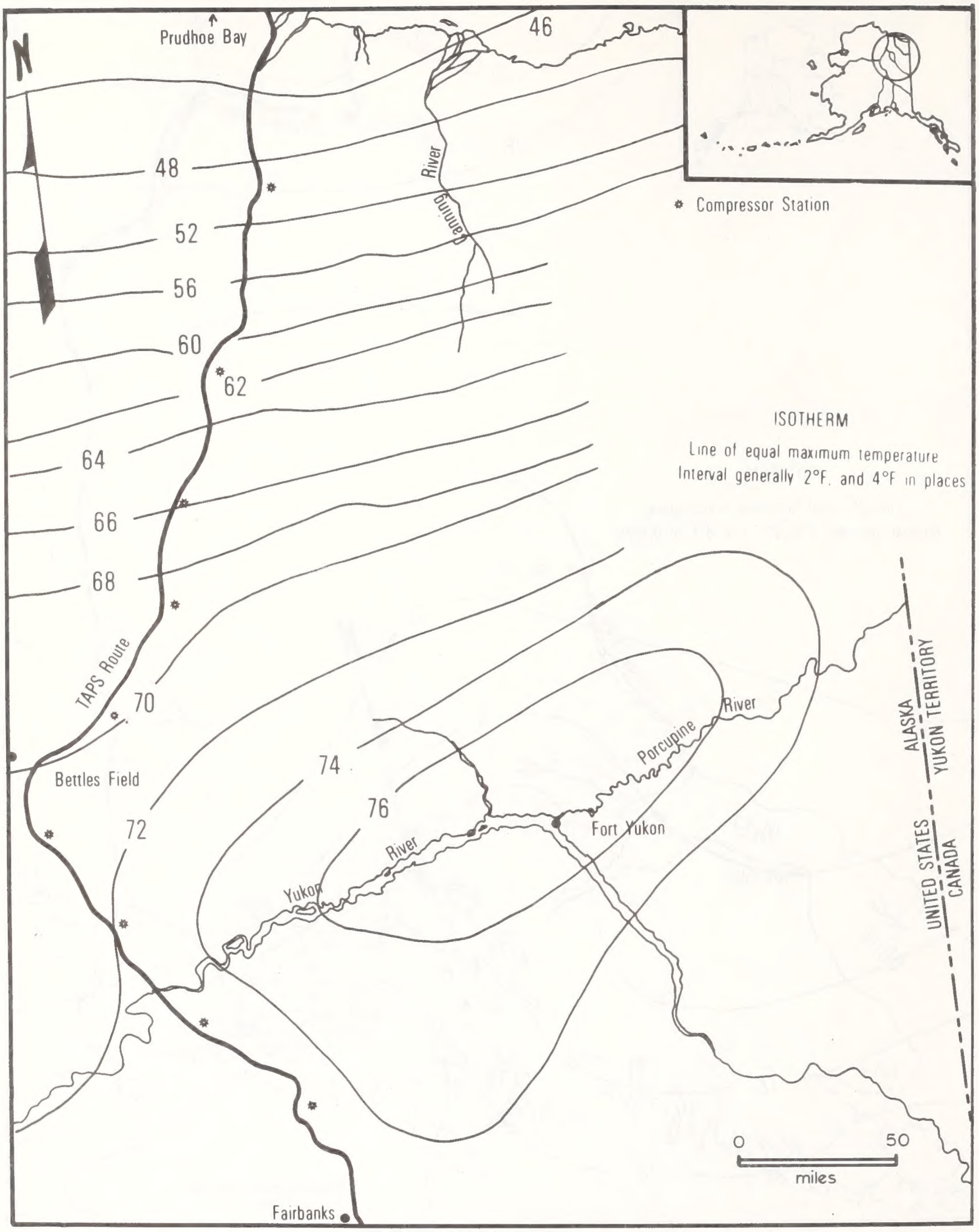


Figure 8.2.1-6a Climate - mean July maximum temperature °F

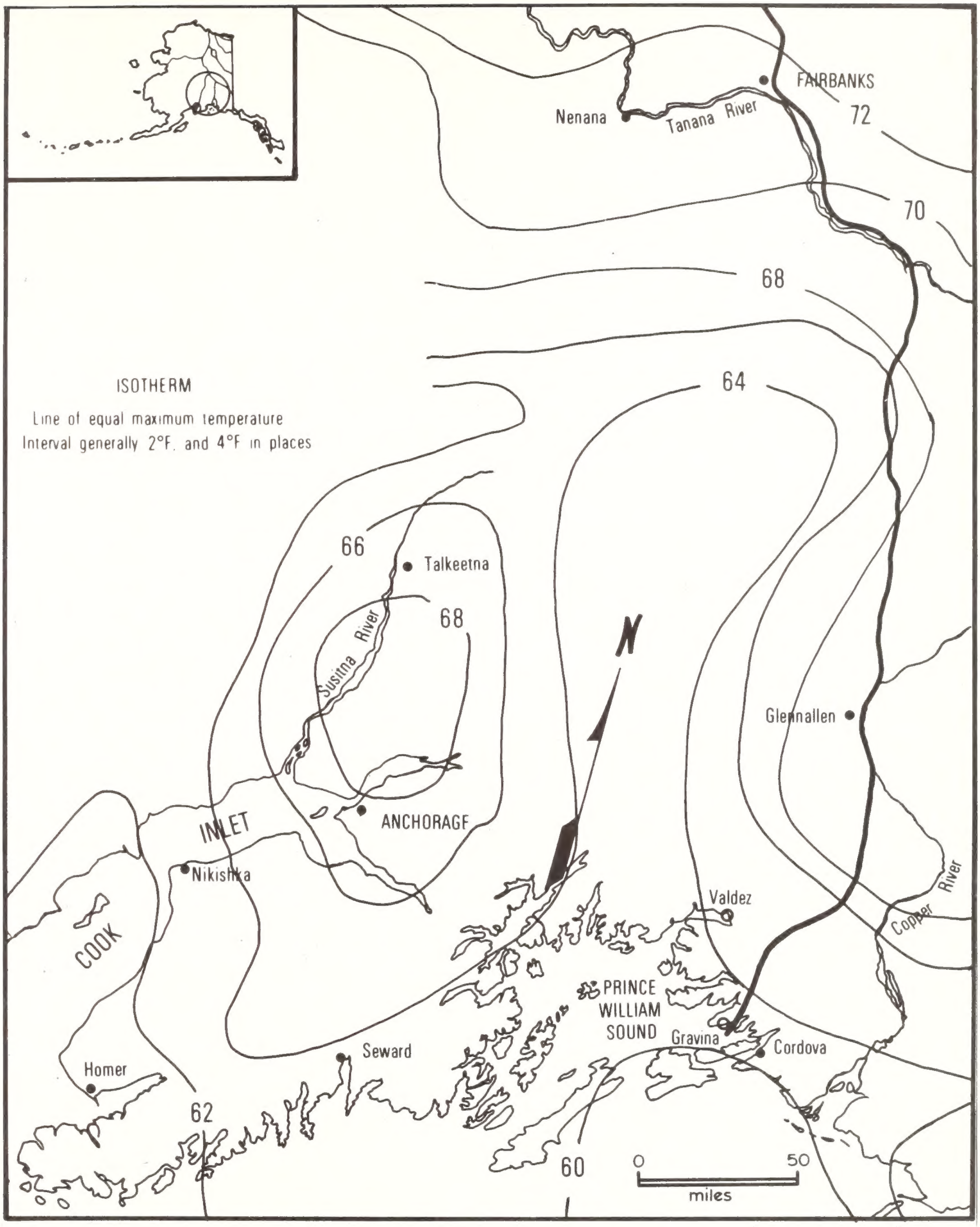


Figure 8.2.1-6b Climate - mean July maximum temperature °F

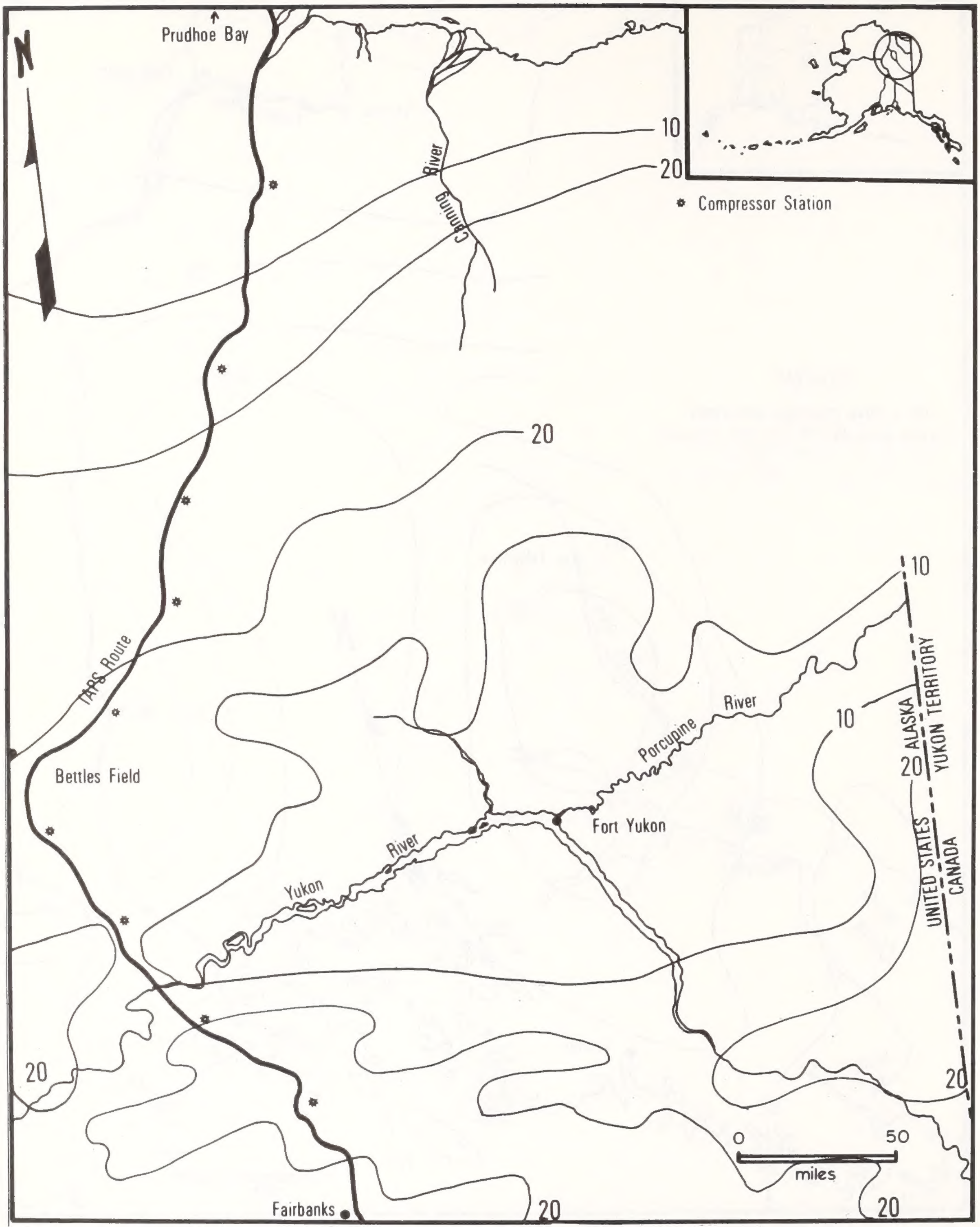


Figure 8.2.1-7a Climate - mean annual precipitation

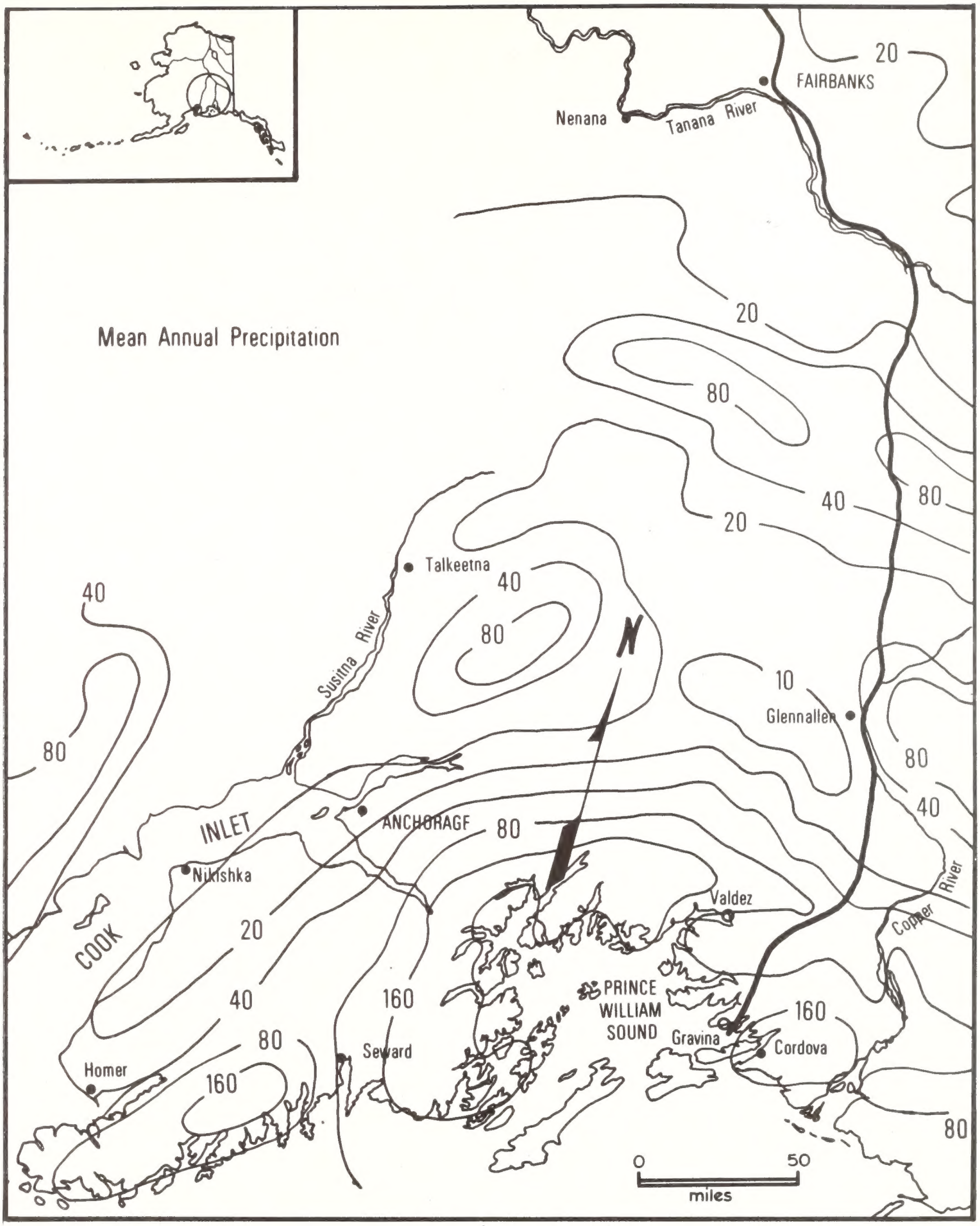


Figure 8.2.1-7b Climate - mean annual precipitation

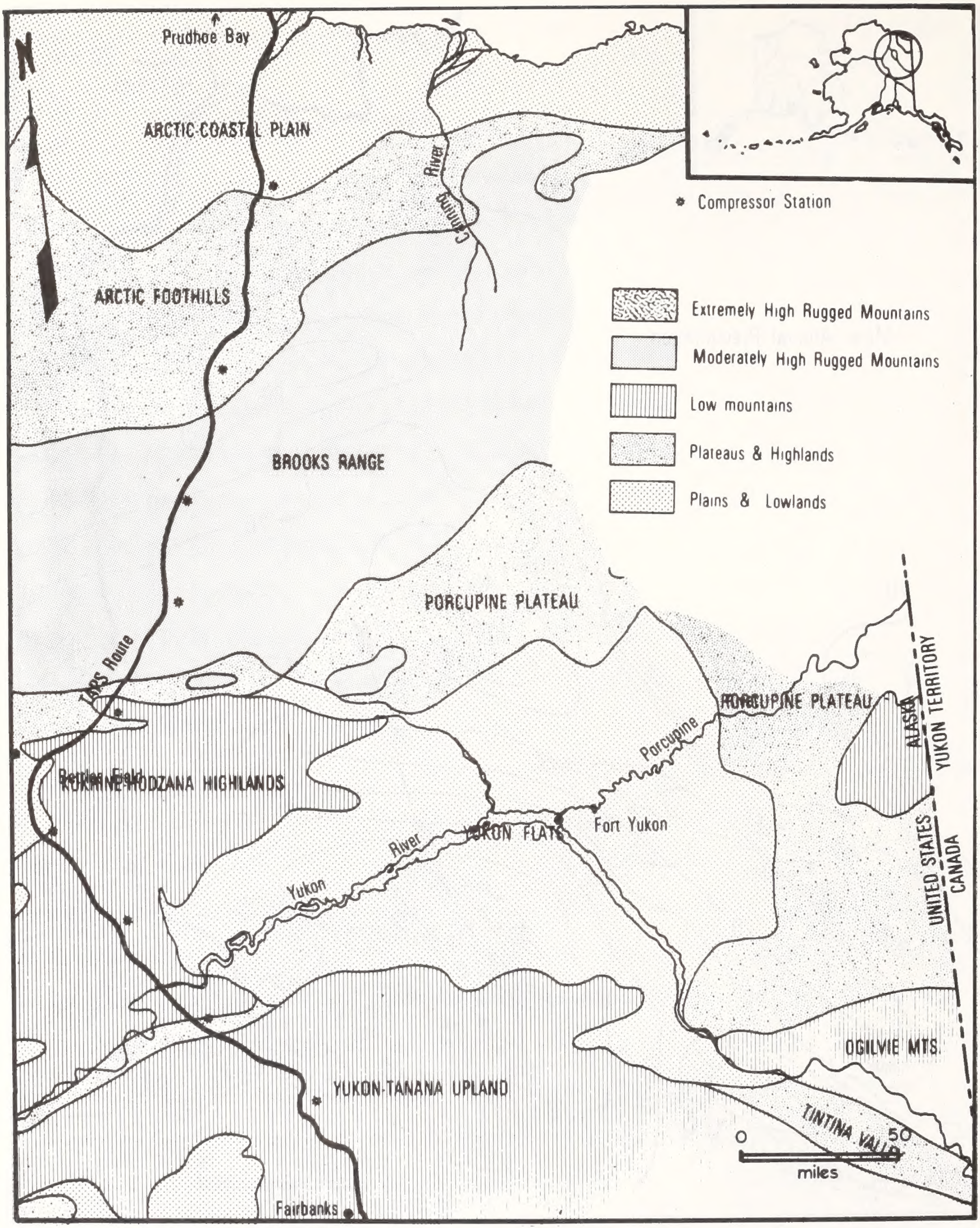


Figure 8.2.1-8a Physiography

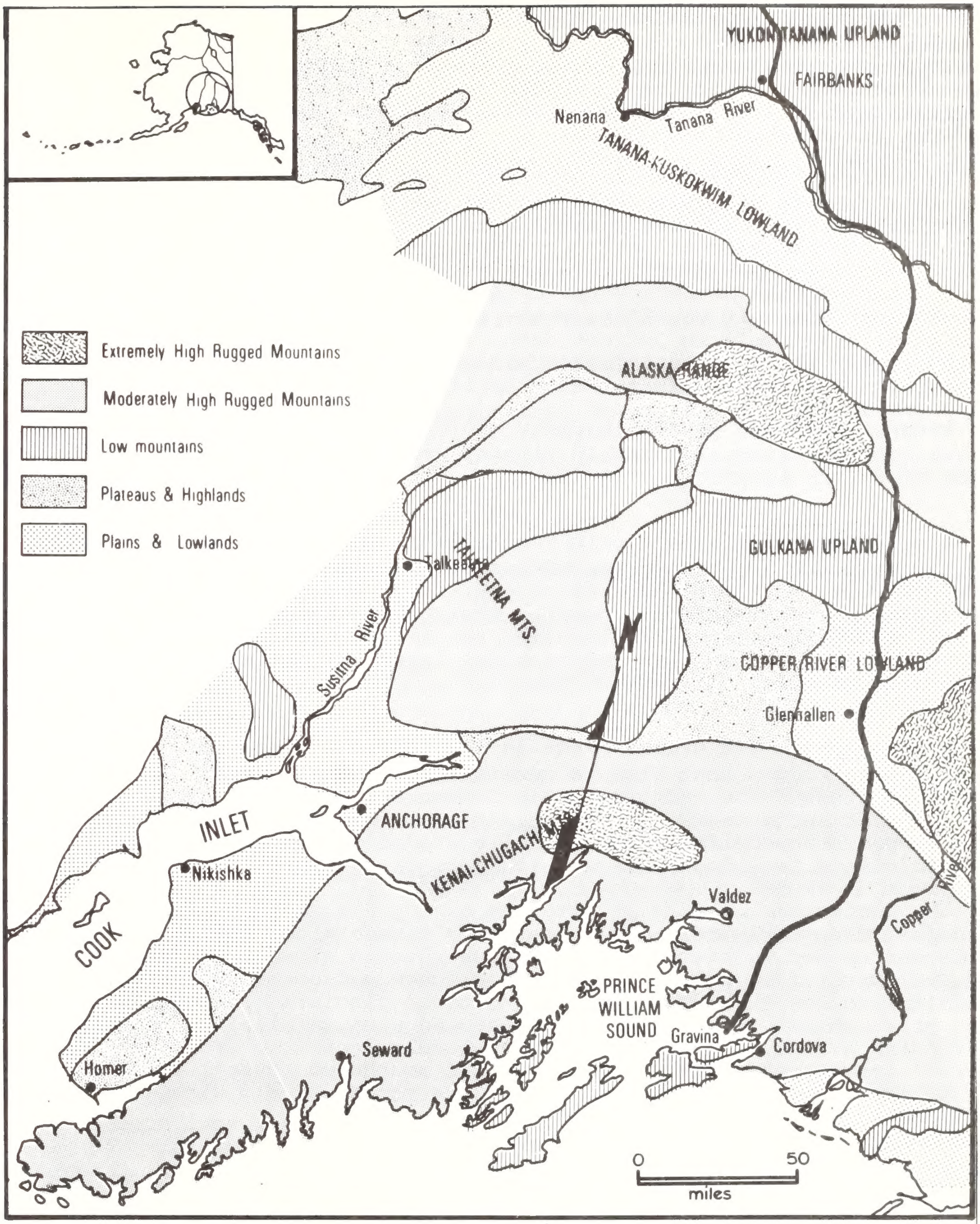


Figure 8.2.1-8b Physiography

southern margin. The coastline makes a very small break in the profile of the coastal plain, and the shore is generally only 1 to 10 feet above the ocean. Pingos (ice-cored hills) are scattered sporadically, across the plain and from a distance may resemble small, very youthful volcanic cones. The coastal plain just west of the delta of the Sagavanirktok River has scattered longitudinal sand dunes.

Initially this alternative pipeline route traverses the Arctic Coastal Plain in a southly direction from Prudhoe Bay up the valley of the Sagavanirktok River. On the coastal plain the Sagavanirktok River has a broad, braided channel.

A large portion of the coastal plain is covered by elongated thaw lakes oriented approximately N. 15° W; these lakes range from a few feet to 9 miles long, are from 2 to 20 feet deep, and generally are oval or rectangular in shape. The lakes expand about 1 meter per year in places, and several generations of drained lake basins are present.

Between MP30 and MP40 this route would pass to the west of the Franklin Bluffs. The terrain is gradually sloping upward to the northern foothills ahead.

Arctic Foothills--The Arctic Foothills in the vicinity of this alternative route are characterized by low, gently rolling hills, broad, U-shaped valleys and flat-topped terraces. There are no significant peaks in this segment of the route alignment. Elevations vary from 500 feet through 2,200 to 1,400 feet, with local relief ranging between 1,000 to 1,500 feet along the route. A few thaw and morainal lakes are present in the valleys and on some divides.

Brooks Range--The Brooks Range is a wilderness of rugged glaciated east-trending ridges that rise to generally accordant summits 7,000 to 8,000 feet in altitude. The easterly grain of the topography is due to belts of hard and soft sedimentary and volcanic rocks. The mountains have cliff-and-bench slopes characteristic of glacially eroded bedded rocks. Abrupt mountain cliffs face foothills and lowlands on the north.

The Continental Divide between the Bering Sea and Arctic Ocean drainages is approximately 5,000 feet in altitude along the pipeline route and is surrounded by steep, rugged, talus-covered slopes. Major rivers (Sagavanirktok) flow north to the Arctic Ocean and south (Dietrich, Chandalar) to the Yukon River in flat-floored glaciated valleys 1/2 to 2 miles wide. Minor tributaries flow east and west parallel to the structure, superposing a trellised pattern on the broadly dentritic drainage of major rivers. Large rock-basin lakes lie at the mouths of several large glaciated valleys on the north and south sides of the range. For a glaciated area, however, the Brooks Range in general has few lakes.

Ambler-Chandalar Ridge and Lowland--The Ambler-Chandalar Ridge and Lowland consists of one or two east-trending lines of lowlands and low passes 3 to 10 miles wide and 200 to 2,000 feet above sea level, bordered on the north by the abrupt front of the Brooks Range. The south side is a discontinuous line of rolling to rugged ridges, 25 to 75 miles long and 5 to 10 miles wide, rising to 3,000 to 4,500 feet in altitude. Some of these ridges were intensively glaciated. Within the lowlands are east-trending ridges 5 to 10 miles long.

The western part of the section is drained by tributaries of the Kobuk River; the central part, by the Koyukuk River and its tributaries; and the eastern part, by the Chandalar River. Most streams flow south out of the Brooks Range across both the lowlands and the ridges to low-lands farther south. Several large lakes fill glacier-carved rock basins in deep narrow canyons across the southern ridge. Areas of ground and end moraines contain many ponds. The flood plains of the major streams have thaw lakes and oxbow lakes.

Kokrine-Hodzana Highlands--The Kokrine-Hodzana Highlands consist of even-topped rounded ridges rising to 2,000 to 4,000 feet in altitude surmounted by isolated areas of more rugged mountains. Valleys have alluviated floors to within a few miles of their heads.

The irregular drainage divide between the Yukon River and its large tributary, the Koyukuk River, passes through these highlands. Drainage to the Yukon is by way of the Hodzana, Tozitna, Melozitna and Dall Rivers and by many shorter streams. Drainage to the Koyukuk is by the Kanuti River and the South Fork of the Koyukuk. There are a few thaw lakes in the lowland areas and a few lakes in north-facing cirques in the Kokrine Hills and the Ray Mountains.

Rampart Trough--The Rampart Trough is a structurally controlled depression having gently rolling topography 500 to 2,500 feet in altitude. The Yukon River enters the northeastern part of the trough through a narrow rocky gorge and swings in broad bends from one side of the trough to the other within a narrow flood plain. The Yukon and its tributaries appear to have been superposed from a surface at least 1,500 feet in altitude. Scattered thaw lakes lie on the Yukon flood plain and elsewhere in the trough.

Yukon-Tanana Upland--The Yukon-Tanana Upland is the Alaskan equivalent of the Klondike Plateau in Yukon Territory. Along with the Rampart Trough and the Kokrine-Hodzana Highlands, it belongs to the Northern Plateaus physiographic province of the Intermontane Plateaus system. Rounded even-topped ridges with gentle side slopes characterize this region of broad undulating divides and flat-topped spurs. In the western part, near the route, these rounded ridges trend northeast to east; they have ridge-crest altitudes of 1,500 to 3,000 feet and rise 500 to 1,500 feet above adjacent valley floors. The ridges are surmounted by compact rugged mountains 4,000 to 5,000 feet in altitude. Valleys in the western part are generally flat, alluvium floored, and 1/4 to 1/2 mile wide to within a few miles of headwaters.

The entire section is in the Yukon drainage basin. Streams flow south to the Tanana River and north to the Yukon River. Most streams in the western part follow courses parallel to the structural trends of bedrock, and several streams have sharp bends involving reversal of direction around the ends of ridges of hard rock. Drainage divides are very irregular. Small streams tend to migrate laterally southward. The few lakes in this section are mainly thaw lakes in valley floors and low passes.

Tanana-Kuskokwim Lowland--The Tanana-Kuskokwim Lowland is a broad depression bordering the Alaska Range on the north; its surfaces are of diversified origin. Coalescing outwash fans from the Alaska Range slope 20 to 50 feet per mile northward to flood plains along the axial streams of the lowland. Rivers from the range flow for a few miles at the heads of the fans in broad terraced valleys 50 to 200 feet deep. Semi-circular belts of morainal topography lie on the upper ends of some fans. Thaw lakes abound in areas of fine alluvium, and thaw sinks are abundant in areas of thick loess cover.

Northern Foothills--The Northern Foothills of the Alaska Range are flat-topped east-trending ridges 2,000 to 4,500 feet in altitude, 3 to 7 miles wide, and 5 to 20 miles long that are separated by rolling lowlands 700 to 1,500 feet in altitude and 2 to 10 miles wide. The foothills are largely unglaciated, but some valleys were widened by glaciers from the Alaska Range. A few small lakes of thaw origin lie in the lowland passes, and morainal areas have hummocky topography and shallow irregular ponds.

Alaska Range--The Alaska Range consists of parallel rugged, glaciated ridges, 6,000 to 9,000 feet high, surmounted by groups of extremely rugged snow-capped mountains more than 9,500 feet high. The ridges are broken at intervals of 10 to 50 miles by cross-drainage or low passes. The range rises abruptly from both sides and its longitudinal profile, seen from a distance, is irregular. Mount McKinley, 20,269 feet high and the highest mountain in North America, is in the central part of the Alaska Range.

This part of the Alaska Range is crossed at places by north-flowing tributaries of the Tanana and Yukon Rivers. The streams are swift and braided, and most rivers head in glaciers. The high mountains are sheathed in ice, and valley glaciers as much as 40 miles long and 5 miles wide radiate from them. For some glaciers (for example, Black Rapids Glacier and Muldrow Glacier) short periods of rapid advance alternated with long periods of stagnation. Short valley glaciers lie in north-facing valleys in the lower parts of the range. Rock glaciers are common and solifluction features are well developed.

Gulkana Upland--The Gulkana Upland consists of subdued east-trending ridges separated by lowlands 2-10 miles wide. The ridge crests are 3,500-5,500 feet in altitude, are 4-15 miles apart, and are cut at intervals of 5-15 miles by notches and gaps that were eroded by glaciers or glacial melt water.

Copper River Lowland--The eastern part of the Copper River Lowland province is a relatively smooth plain, 1,000-2,000 feet in altitude trenched by the valleys of the Copper River and its tributaries, which have steep walls 100 to 500 feet high. The Copper River and most of its tributaries head in glaciers and have braided upper courses. Large lakes occupy deep basins in the mountain fronts and thaw lakes are abundant in the eastern plain. Saline ground water has formed salt springs and mud volcanoes.

The route is located west of the Copper River across this entire physiographic unit. Major rivers crossed include the Gulkana, Tazlina, and Klutina.

Kenai-Chugach Mountains--The Kenai-Chugach Mountains form a rugged barrier along the north coast of the Gulf of Alaska. High segments of the mountains are dominated by extremely rugged east-trending ridges 7,000 to 13,000 feet high. Low segments consist of discrete massive mountains 5 to 10 miles wide and 3,000 to 6,000 feet high, separated by a system of valleys and passes 1/2 to 1 mile wide. The entire range has been heavily glaciated, and the topography is characterized by horns, aretes, cirques, V-shaped valleys and passes, and rock-basin lakes. The coast is indented by fiords and sounds, and ridges extend southward as chains of islands. The north front is an abrupt mountain wall. The range is drained by short, swift streams, most of which head in glaciers. All higher parts of the range are buried in great ice fields from which valley and piedmont glaciers radiate. Most of the glaciers on the south side of the mountains end in tide water.

From north to south, the route lies generally within a mile of the Alyeska Pipeline route through the Tonsina-Tiekel-Tsina drainage system, across Thompson Pass and into the Lowe River Valley. At approximately MP 765 the Alaska Gas Pipeline proposes to leave the Alyeska corridor to proceed generally southward. Utilizing the gentler grades of stream courses, it will rise out of the Lowe River Valley, across a ridge at about 3,500 feet elevation and descend to parallel the north shore of Port Fidalgo to the Gravina River. It will ascend that valley before turning southwestern onto Gravina Peninsula, passing around Beartrap Bay, beneath Comfort Cove and into the proposed terminal site at MP 810.2.

Geology and Soils

Mineral Resources--Oil--The areas north of the Brooks Range exhibits proven potential for large deposits of oil and gas. Lacking systematic tests through drilling, the extent and value of the fields can not be quantified.

Within the Copper River Basin an oil province has been identified (Gates *et al*., 1968). It is not, however, considered among the more attractive Alaska opportunities at this time. The first oil production in Alaska was at Katalla, to the east of Prince William Sound, but the field has been inactive for several decades.

Off-shore petroleum potential is generating considerable interest at this time. The Gulf of Alaska is among the prime targets.

Figures 8.2.1-9a and 9b show the potential sedimentary basins crossed by the pipeline.

Coal--Subbituminous and lignitic coals are known to occur in the area north of the Brooks Range. Reserves were identified by the presence of surface outcropping and no exploration effort has been attempted to identify the extent of the field or fields.

Scattered outcrops of subbituminous and lignite coals occur north and south of the Brooks Range and north of the Alaska Range. Reserves within 50 miles either side of the route exceed 77 million ton (Figures 8.2.1-10a and 10b).

Geothermal--There are no identified reserves but the route passes near an area with high potential north of the Brooks Range. Another area of high potential is encountered near the corridor north of the Alaska Range. The Circle Hot Springs area to the east of the Corridor may also have developmental potential.

Minerals--Phosphates are known to underlie a large area north of the Brooks Range.

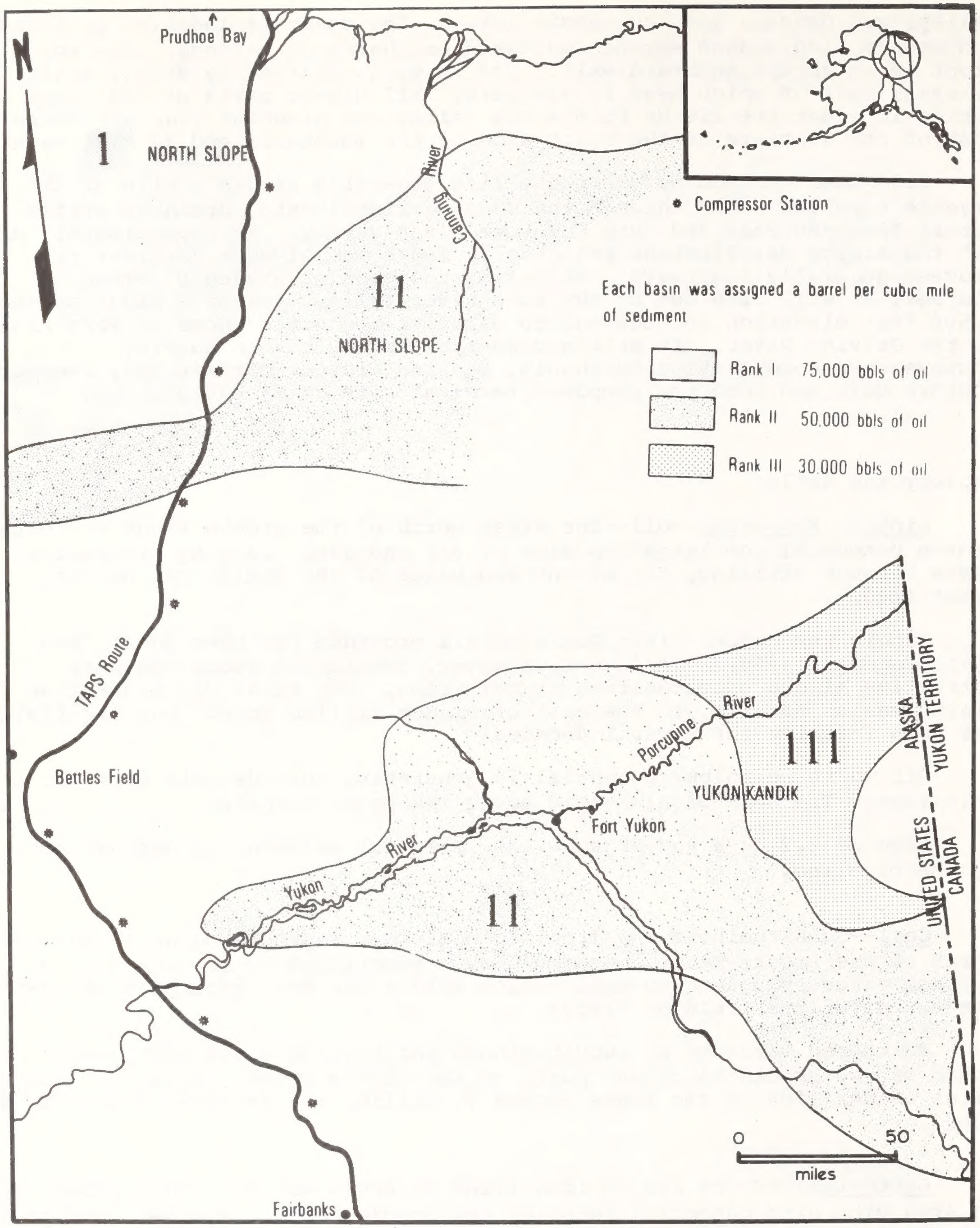


Figure 8.2.1-9a Petroleum

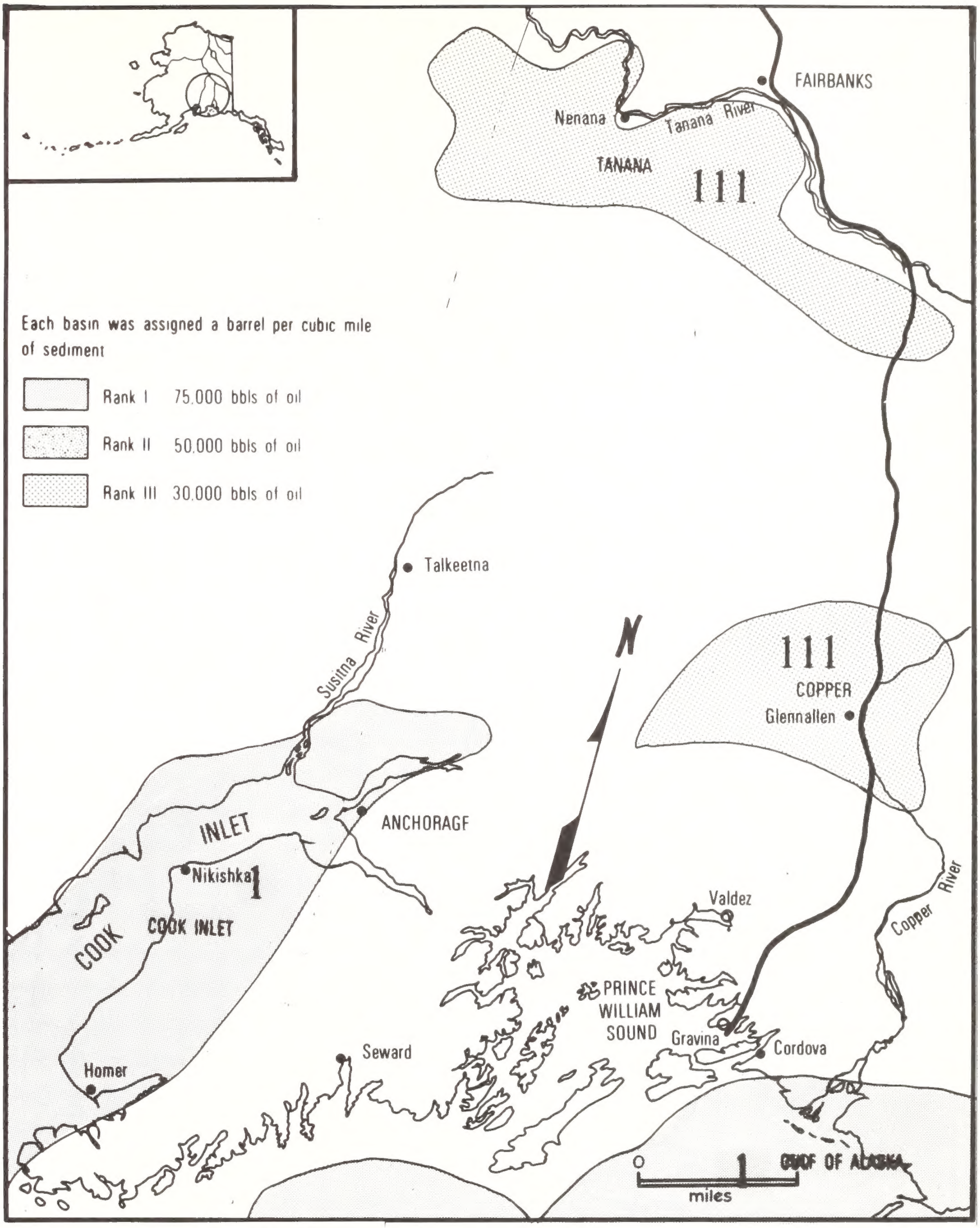


Figure 8.2.1-9b Petroleum

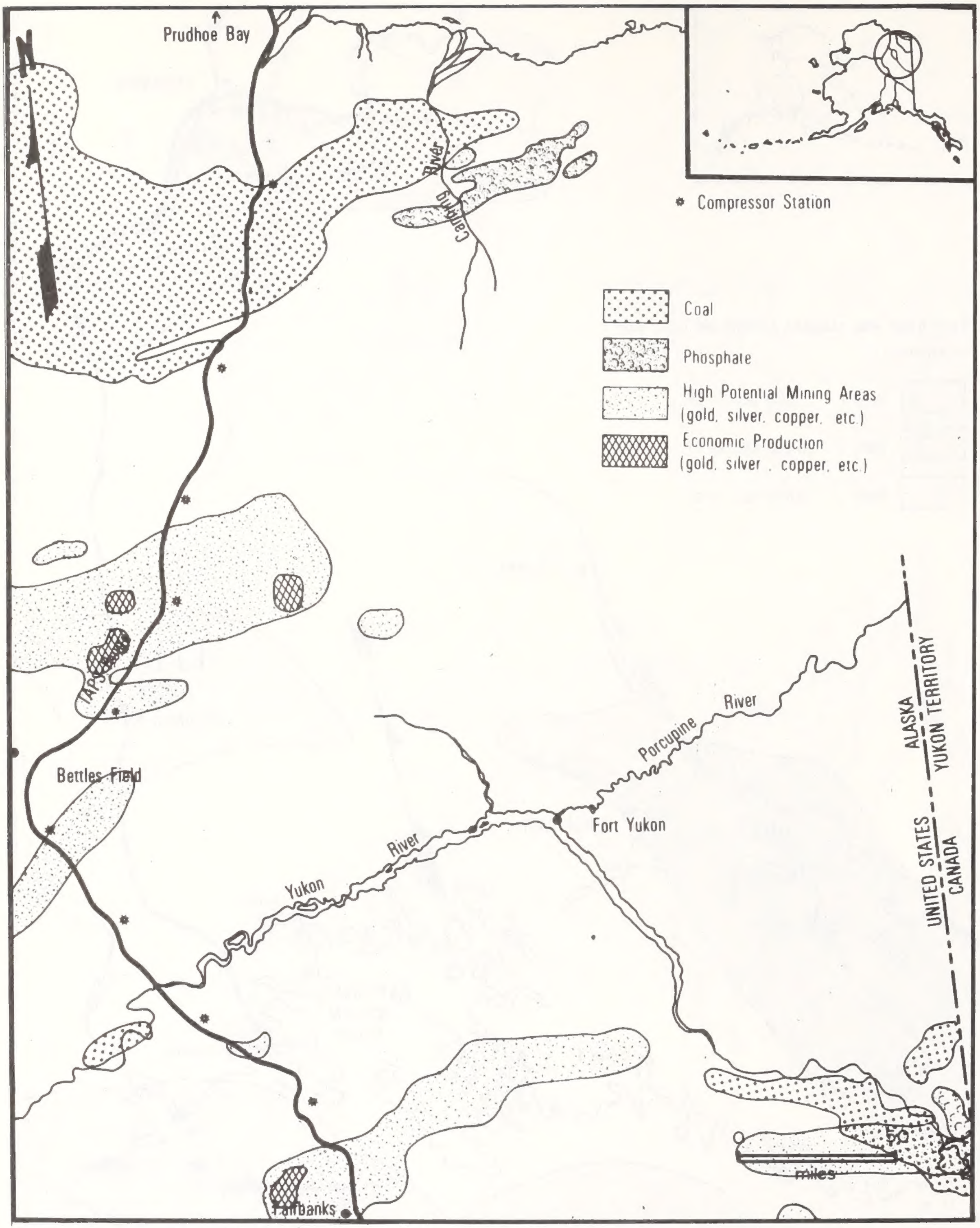


Figure 8.2.1-10a Minerals

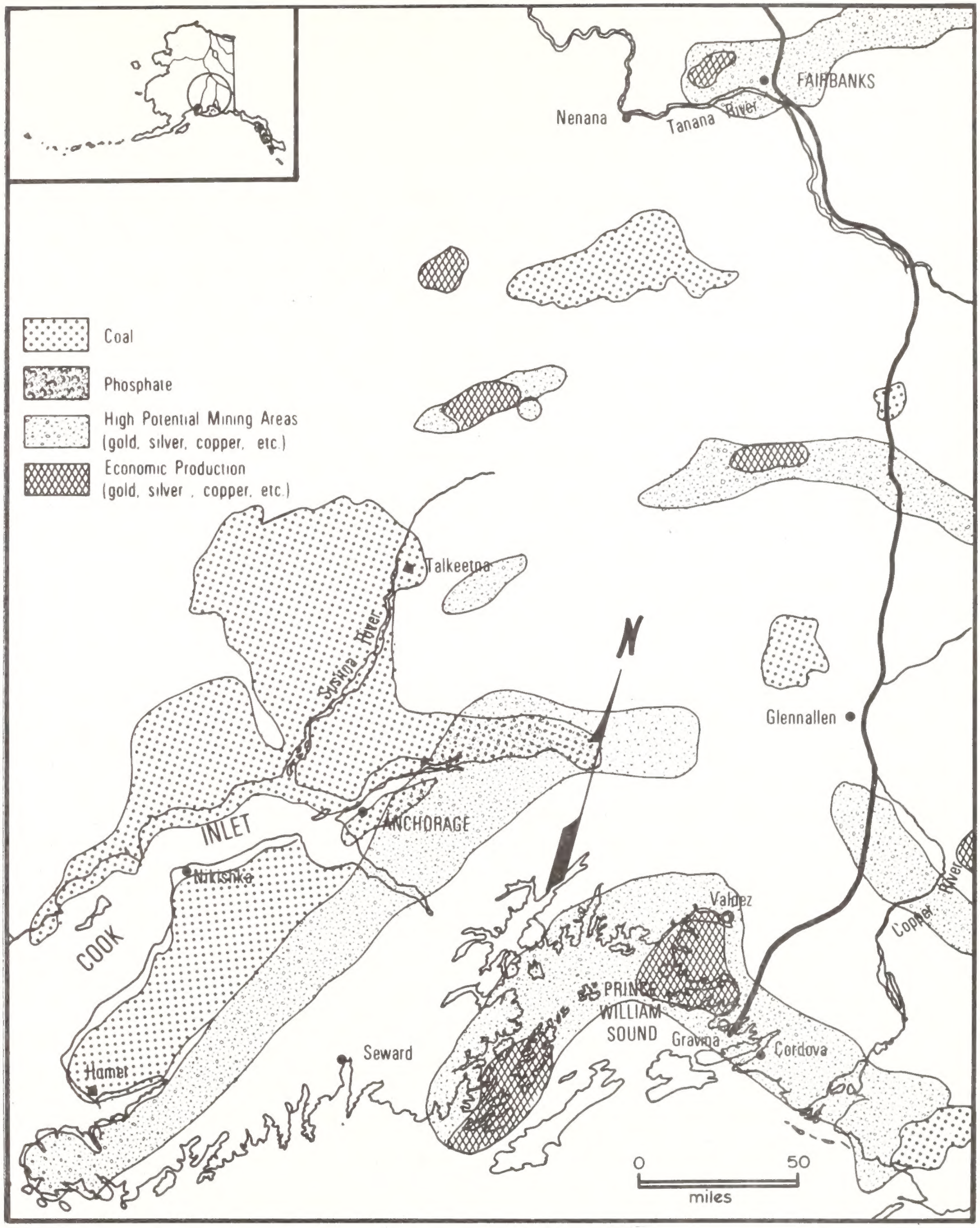


Figure 8.2.1-10b Minerals

There is potential for finding gold, lead, copper, zinc, tin, tungsten and fluorite throughout the corridor. Potential for development is unknown due to lack of exploration.

A large number of claims exist along the south flank of the Brooks Range and in the Livengood and Fairbanks areas. Most of these claims are for placer gold; however, many are for copper, lead, zinc, and antimony.

The pipeline would cross many metallogenic provinces starting in the Brooks Range and going south. Most of these provinces have good to high potentials for gold, lead, zinc, antimony, and molybdenum. The mineral potential remains high south into the Prince William Sound area. Generalized mineral areas are shown in Figures 8.2.1-10a and 10b.

Gravel and Sand--Large amounts of gravel and sand are being required for the Alyeska Oil Pipeline construction effort. Contracts let to date are expected to result in the extraction of nearly 190 million cubic yards. While there is no estimate of the reserves of gravel and sand that will remain after construction of the oil pipeline, additional demand of comparable proportions could deplete these resources in certain localities. Where such depletion is expected, substitute aggregates should be used wherever practicable.

Stratigraphy and/or Lithology--Figures 8.2.1-11a and 11b provide a graphic display for the following text.

Bedrock--The Arctic Coastal Plain is underlain by 10 to more than 150 feet of unconsolidated Quaternary marine sediments, made up largely of carbonaceous pebbly silt and silty sand overlying sandy gravel. These rocks rest on nearly flat-lying Cretaceous and, in several areas, lower Tertiary sedimentary rocks.

The northern part of the Arctic Foothills is underlain by semi-consolidated Tertiary sand and gravel and Cretaceous sandstone, siltstone, and shale. These rocks are predominantly gently dipping; however, locally they have been deformed into longer linear folds. They are exposed west of the Kavik River in the low, smooth, broad hills where they are beyond the glacial drift cover. Bedrock is exposed only in small isolated localities in the southern foothills because of the extensive mantle of young glacial deposits. The bedrock in this area is gently folded and occasionally faulted. It is made up of quartzitic sandstone and siltstone, shale, and conglomerates ranging in age from Cretaceous to Permian.

Between Coldfoot and the South Fork of the Koyukuk River ridges are composed in part of resistant massive greenstone (metamorphosed basalt) of Mesozoic age. The lowlands are underlain largely by Cretaceous sedimentary rocks, folded into anticlines and synclines. Pleistocene glaciers from the Brooks Range extended across the lowland and through passes in the line of ridges.

This section of the route is underlain by unconsolidated deposits consisting of frozen glacial silt, sand, and gravel, colluvial silts, alluvium, and conglomeratic sandstone bedrock. The unconsolidated deposits are generally ice-rich and include ice wedges, lenses, and interstital ice. Locally, the glacial deposits are thawed.

Between the Koyukuk and Hess Creek the highlands are underlain chiefly by Paleozoic and Precambrian schist and gneiss having a northeast-trending structural grain, cut by several granitic intrusions, the largest of which is the granite batholith that upholds the Ray Mountains.

The route is underlain by unconsolidated deposits consisting of frozen colluvial silts, sands, and rock fragments, glacial sand and gravel, reworked windblown silts, lake sediments, and stream sand and gravel, and small areas of bedrock consisting of gabbro, diabase, basalt, chert, and schist.

Much of the area, especially south of the Yukon River, is underlain by ice wedges and lenses. In local areas north of the river, ice wedge polygons, solifluction lobes, and ice lenses occur. In this area the fine-grained sediments are ice-rich and easily erodible.

In the vicinity of Hess Creek the Rampart Trough was eroded along a tightly folded belt of soft continental coal-bearing rocks of Tertiary age. Hard-rock hills and the surrounding uplands are partly metamorphosed sedimentary and volcanic rocks of Mississippian age that strike about N. 60° E. and are cut by granitic intrusions.

This segment of the route is underlain by frozen, colluvial silts, sand, and rock fragments, stream gravel, and ice-rich reworked windblown silt. The route crosses over a small bedrock area underlain by extrusive and intrusive volcanic and sedimentary rocks. The ice-rich fine-grained sediments and the colluvial debris are easily erodible.

South of Hess Creek to the Shaw Creek Flats, the route is on a belt of highly deformed Paleozoic sedimentary and volcanic rocks containing conspicuous limestone units, overthrust and overturned to the north, which extends along the north side of the upland. The rest of the upland is chiefly Precambrian schist and gneiss but has scattered small elliptical granitic intrusions in the northwestern part; large irregular batholiths make up much of the southeastern part. In the western part a thick mantle of windblown silt lies on the lower slopes of hills, and thick accumulations of muck (frozen fine-grained sediments with a high organic content) overlie deep stream gravels in the valleys. Pingos are common in valleys and on lower hill slopes.

The route is underlain by reworked windblown silt, colluvial silt, sand and rock fragments, alluvial silt, sand and gravel, and dune sand. Locally, the unconsolidated deposits are absent or occur as a thin veneer over bedrock which consists chiefly of schist, dolomite, limestone, granite, and volcanic rocks. North of Fairbanks the unconsolidated sediments are generally frozen and locally ice-rich. Ice forms include wedges, lenses, and interstitial ice. South of Fairbanks, much of the area is thawed; however, there are large accumulations of ice in some of the sediments, especially the fine-grained reworked silt.

Near the Alaska Range the outwash fans grade from coarse gravel to sand and silt along the axial streams. Areas north of the axial streams are underlain by thick deposits of muck. Parts of the southwestern part of the lowland have thick loess cover, but the central and eastern parts are free of loess south of the Tanana River. Scattered low hills of granite, ultramafic rocks, and Precambrian schist rise above the outwash. Tertiary conglomerate in the foothills of the Alaska Range plunges beneath the lowland in a monocline, and the heads of the outwash fans may rest on a pediment cut across the conglomerate.

Through the northern foothills province, crystalline schist and granitic intrusive rocks make up most of the ridges. Poorly consolidated Tertiary rocks underlie the lowlands.

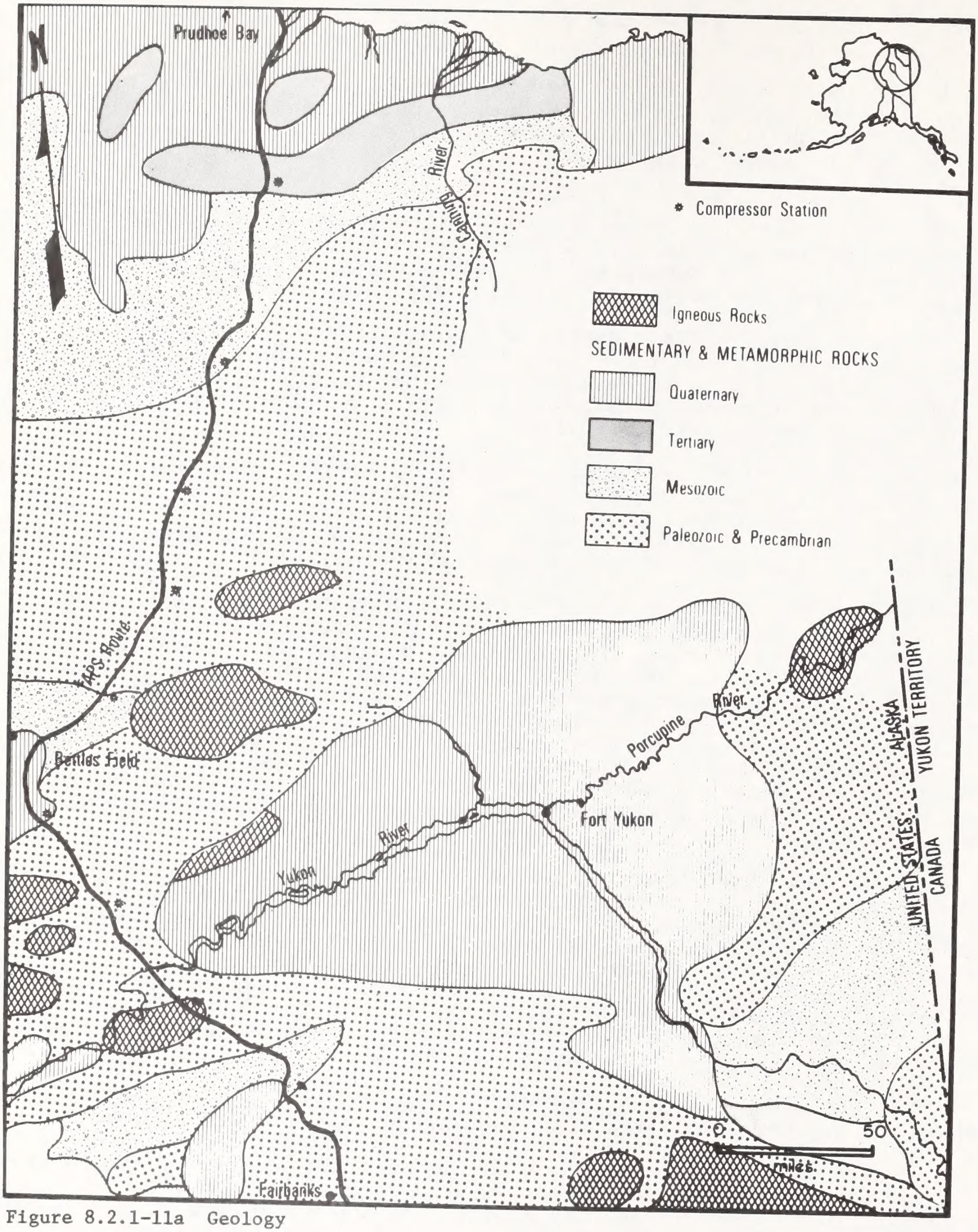


Figure 8.2.1-11a Geology

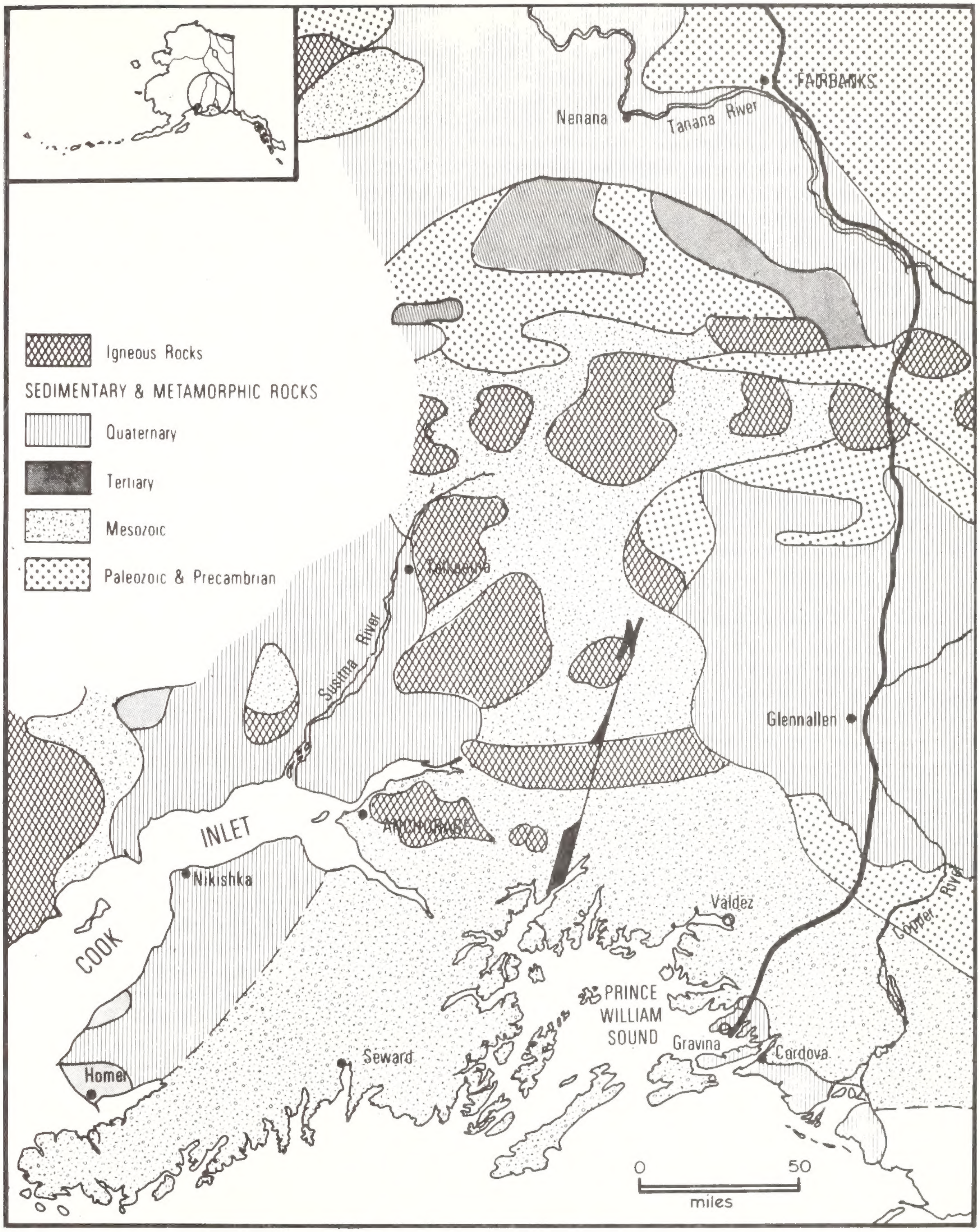


Figure 8.2.1-11b Geology

In this area the route follows the Delta River valley, crossing an area underlain generally by glacial deposits including till and stratified drift, but limited areas of bedrock do occur in the southern part. The glacial deposits are commonly frozen, dense granular deposits overlain by a thin silt cover. These frozen soils generally have a low ice content; however, locally ice-rich soils have been encountered.

Further south, the Alaska Range is complex synclinorium with Cretaceous rocks in the center and Paleozoic and Precambrian rocks on the flanks. Many roughly oval granitic stocks and batholiths support groups of high mountains. Tertiary rocks underlie lowlands that trend parallel to the length of the range. The synclinorium is cut by great longitudinal faults that trend approximately parallel to the length of the range and are marked by lines of valleys and low passes. Recently formed scarplets as high as 30 feet can be seen on several longitudinal faults. One of these faults, the Denali, is an active major tectonic feature that extends in a great arc across Alaska from the Yukon Territory in Canada to the Bering Sea. In the central and eastern Alaska Range, the fault is characterized by high levels of microearthquake activity (Boucher and Fitch, 1969; Page, 1971) and substantial Holocene right-lateral strike-slip displacement, ranging up to 300 m. (Ritcher and Matson, 1971). Measurements for slip in the vicinities of the Alaska Railroad and the Richardson Highway indicate that this segment of the fault has been locked since at least 1942. This route will cross the Denali Fault.

The Gulkana province is typified by lowlands floored by glacial deposits showing morainal and stagnant ice topography and, in the Tangle Lakes area, contains large esker systems. Many long, narrow lakes occupy rock-cut basins in notches through the ridges. Irregular lakes abound in some areas of morainal topography. The upland is underlain by discontinuous permafrost and contains altiplanation terraces.

Bedrock is chiefly greenstone with interbedded sediments, both of which are cut by large granitic intrusions. These rocks are of late Paleozoic and Mesozoic age; structure trends eastward. Areas of relatively low relief in the northern part are underlain by poorly consolidated Tertiary sedimentary rocks.

Bedrock beneath the southern part of the Copper River Lowland is chiefly easily eroded sandstone and shale of Mesozoic age; bedrock beneath the northern part is chiefly resistant late Paleozoic and Mesozoic metamorphosed volcanic rock with granitic intrusions. Tertiary gravels cap some hills in the southwestern part of the basin. Glacial drift mantles much of the basin. The eastern part is underlain by glaciolacustrine and glaciofluvial deposits at least 500 feet thick.

The Kenai-Chugach Mountains are composed of metamorphosed argillite, graywacke, and greenstone (mostly of Mesozoic age). A belt of Paleozoic and Mesozoic schist, greenstone, chert, and limestone lies along the north edge of the mountains. The Kenai-Chugach Mountains are extremely active tectonically, which is demonstrated by the large number of earthquakes occurring in this section, and undoubtedly, active faults are present. The existence of faults also is indicated by the presence of several conspicuous structural lineaments (Coulter and Coulter, 1951, 1962). However, it is difficult to locate fault zones in thia area because of the uniform character of the bedrock and because of its altered or metamorphosed cond.

Soils--Soils along the route are summarized in Figures 8.2.1.-12a and 12b and Tables 8.2.1.-3, 4 and 5.

Soils of the Arctic Coastal Plain and Foothills are well drained gravelly brown soils, well drained gravelly or sandy soils and poorly drained medium-textured peaty soils of the coastal tundra and uplands. Erosion potentials are low to moderate.

Only the gravelly soils of steep slopes and sandy soils of drainages are relatively well drained and permafrost-free in the upper layer. The thin mantle of gravelly soils along the drainages through the Brooks Range is permafrost-free.

Soils of this route as summarized in the following table are predominantly poorly-drained, medium-textured soils with peaty surface layers and permafrost in drainages of major rivers, narrow stream valleys and on low slopes. Well-drained gravelly brown soils without permafrost occupy extensive areas on south slopes of hilly uplands in the Yukon-Tanana-Kokrine-Hodzana Highlands from the East fork drainage to the Tanana Valley area.

From Fairbanks to the Delta area, there are intermittent permafrost soils on the uplands, permafrost free alluvial soils along the Tanana River and wet loamy soils with continuous permafrost in other drainages.

South of Fairbanks along the route moderately deep and well-drained brown upland soils are most extensive. These are deep and loamy textured in the Fairbanks and Birch-Harding Lakes area, occupying moderate slopes of the highlands.

Stratified sandy alluvial soils occupy river terraces along the Tanana River from Fairbanks to the Birch Lake area. Wet, loamy soils with a thick overlying peat layer occupy low areas along drainages, extending to low gravelly slopes of the uplands along the upper Tanana. The soil surveys of the Fairbanks-Salcha-Big Delta areas by Schoephorster, 1973 describe soils of the area in detail.

Poorly-drained gravelly soils with permafrost occupy high drainages within the Alaskan Range. Wet soils of valley floors in the northern Alaska Range foothills are loamy with an overlying peat layer, interspersed with sandy gravelly alluvium. Predominant upland soils are well-drained brown gravelly textured soils occupying the south slopes of Alaska Range and north slopes of the Chugach Range surrounding the Gulkana Basin. (SCS, 1974).

Soils of the Gulkana Basin are deep and poorly-drained, interlayered silts and clays overlain by a thick peat mat. Permafrost is nearly continuous. This mantle occupies a glacial lake basin having fine materials deposited to great depth. (SCS, 1974).

Soils of the mountain valleys through the Chugach Range are well-drained, shallow, and gravelly with permafrost. In the Valdez area, gravelly wet soil without permafrost occupy valley bottoms along the Lowe River. The Gravina Route extends through rockland in the mountain passes and down over the well-drained gravelly loams of moraines and footslopes to the Gravina Point plant site. Peat soils occupy positions on the moraines and low slopes interspersed with the well drained gravelly loams (SCS, 1974).

Permafrost--Permafrost is a critical geological-climatological phenomenon that is central to this environmental impact statement. Permafrost is defined as soil, rock, or any other earth material, the temperature of which remains at or below 32° F (0°C) continuously for two or

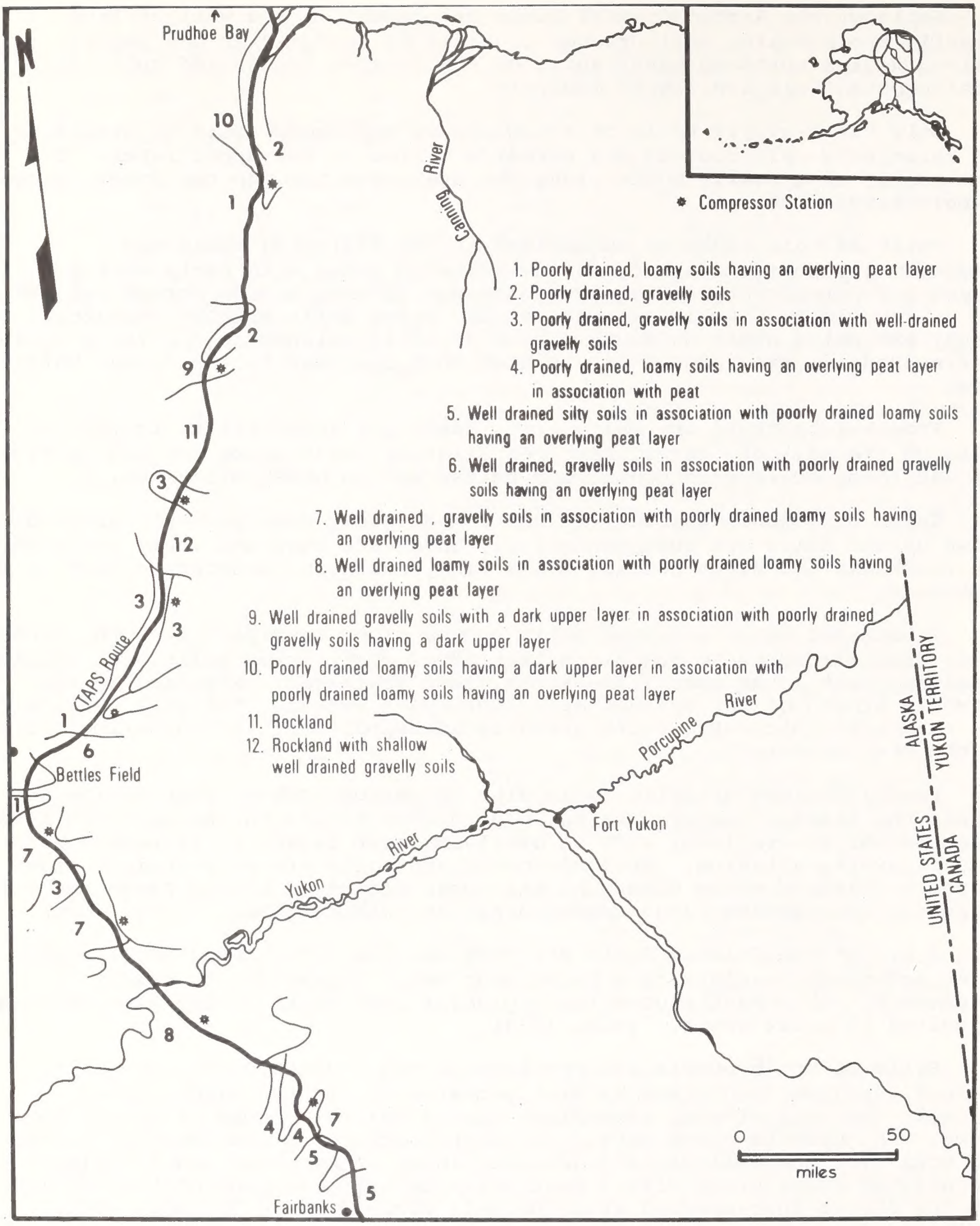

N
Prudhoe Bay
River
Canning
Compressor Station
1. Poorly drained, loamy soils having an overlying peat layer
2. Poorly drained, gravelly soils
3. Poorly drained, gravelly soils in association with well-drained gravelly soils
4. Poorly drained, loamy soils having an overlying peat layer in association with peat
5. Well drained silty soils in association with poorly drained loamy soils having an overlying peat layer
6. Well drained, gravelly soils in association with poorly drained gravelly soils having an overlying peat layer
7. Well drained , gravelly soils in association with poorly drained loamy soils having an overlying peat layer
8. Well drained loamy soils in association with poorly drained loamy soils having an overlying peat layer
9. Well drained gravelly soils with a dark upper layer in association with poorly drained gravelly soils having a dark upper layer
10. Poorly drained loamy soils having a dark upper layer in association with poorly drained loamy soils having an overlying peat layer
11. Rockland
12. Rockland with shallow well drained gravelly soils
TAPS Route
Bettles Field
Porcupine
River
Fort Yukon
Yukon
River
ALASKA
YUKON TERRITORY
UNITED STATES
CANADA
0
50
miles
Fairbanks
10
2
1
2
9
11
3
12
3
3
1
6
1
7
3
7
8
4
4
7
5
5

Figure 8.2.1-12a Soils

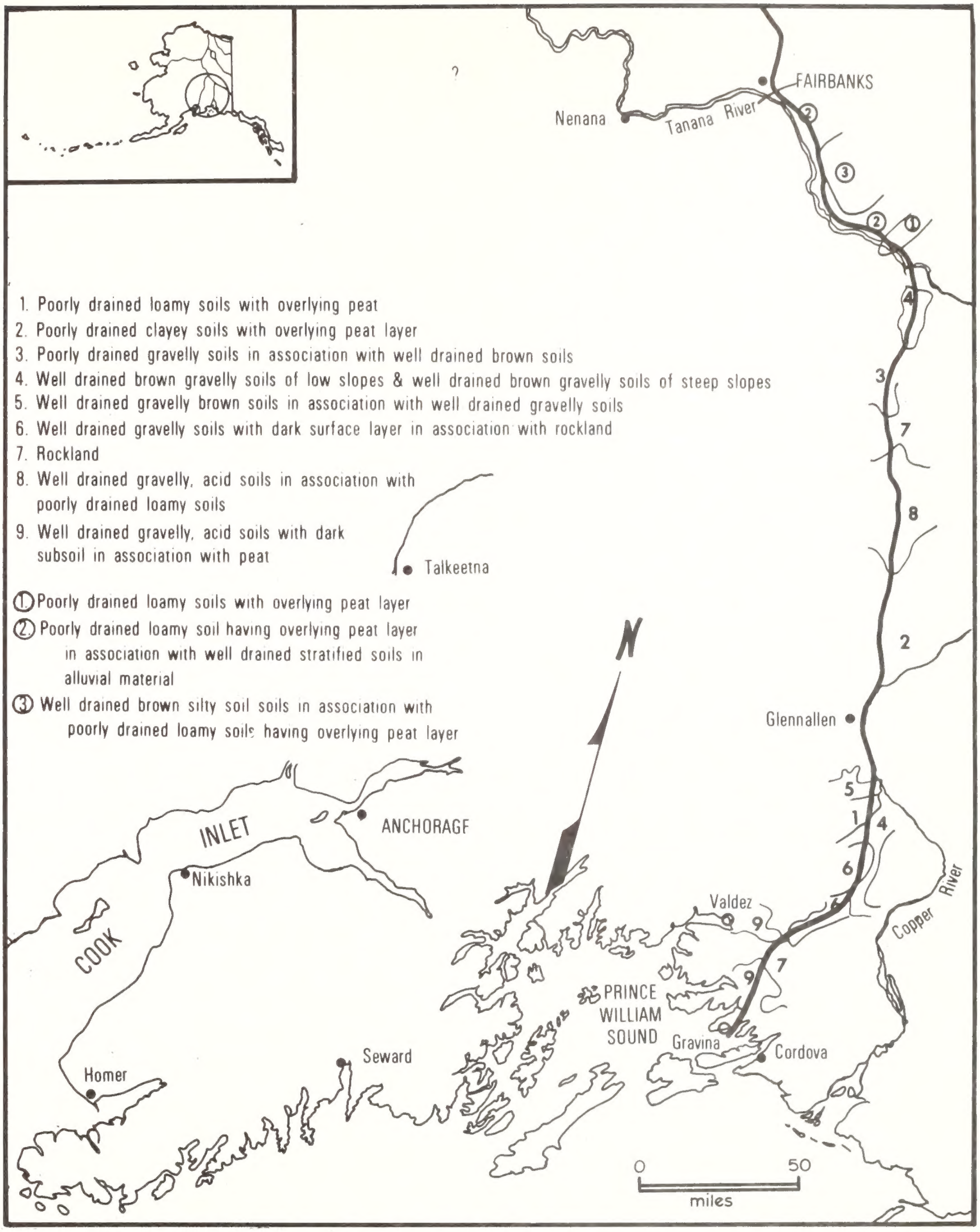

FAIRBANKS
Nenana
Tanana River
1. Poorly drained loamy soils with overlying peat
2. Poorly drained clayey soils with overlying peat layer
3. Poorly drained gravelly soils in association with well drained brown soils
4. Well drained brown gravelly soils of low slopes & well drained brown gravelly soils of steep slopes
5. Well drained gravelly brown soils in association with well drained gravelly soils
6. Well drained gravelly soils with dark surface layer in association with rockland
7. Rockland
8. Well drained gravelly, acid soils in association with poorly drained loamy soils
9. Well drained gravelly, acid soils with dark subsoil in association with peat
① Poorly drained loamy soils with overlying peat layer
② Poorly drained loamy soil having overlying peat layer in association with well drained stratified soils in alluvial material
③ Well drained brown silty soil soils in association with poorly drained loamy soils having overlying peat layer
Talkeetna
N
Glennallen
ANCHORAGE
INLET
COOK
Nikishka
Valdez
Copper River
PRINCE WILLIAM SOUND
Gravina
Cordova
Seward
Homer
0
50
miles

Figure 8.2.1-12b Soils

Table 8.2.1-3 Soils, Prudhoe Bay to Fairbanks

Soil No.	Description	Miles	Percent of total line	Location
1.	Poorly drained, loamy soils having an overlying peat layer	122	27.0	Arctic foothills Koyukuk River Valley
2.	Poorly drained, gravelly soils	14	3.0	Arctic Coastal Plain
3.	Poorly drained, gravelly soils in association with well-drained gravelly soils	18	4.0	South slopes of Brooks Range
4.	Poorly drained, loamy soils having an overlying peat layer in association with peat	11	2.0	Tolovana River Valley
5.	Well drained silty soils in association with poorly drained an overlying peat layer	13	3.0	Yukon Uplands
6.	Well drained, gravelly soils in association with poorly drained gravelly soils having an overlying peat layer	19	4.0	Uplands adjacent to Koyukuk River
7.	Well drained, gravelly soils in association with poorly drained loamy soils having an overlying peat layer	82	18.0	Kokrine, Hodzana and Yukon Highlands
8.	Well drained loamy soils in association with poorly drained loamy soils having an overlying peat layer	54	12.0	Yukon Highland

Table 8.2.1-3 Continued

9.	Well drained gravelly soils with a dark upper layer in association with poorly drained gravelly soils having a dark upper layer	24	5.0	Upper foothills of Brooks Range
10.	Poorly drained loamy soils having a dark upper layer in association with poorly drained loamy soils having an overlying peat layer	61	13.0	Arctic coastal Plains
11.	Rockland	20	4.0	Brooks Range
12.	Rockland with shallow well drained gravelly soils	15	3.0	Brooks Range
	Total	453	98.0	

Table 8.2.1-4 Soils, Fairbanks to Delta Junction

Soil No.	Description	Miles	Percent of Route	Location
①	Poorly drained loamy with overlying peat layer	10	12.0	Salchia Creek
②	Poorly drained loamy soil having overlying peat layer in association with well drained stratified soils in alluvial material	28	34.0	Tanana River in the Fairbanks, Salcha and Delta areas
③	Well drained brown silty soils in association with poorly drained loamy soils having overlying peat layer	45	54.0	Uplands
	Total	83	100.0	

Table 8.2.1-5 Soils, Delta Junction to Gravina Point

Soil #	Description	Miles	Percent of route	Location
1.	Poorly drained loamy soils with overlying peat layer.	64	22.	Gulkana Basin
2.	Poorly drained clayey soils with overlying peat layer.	7	3.	Willow Mtn-Tonsina area
3.	Poorly drained gravelly soils in association with well drained brown soils.	27	10.	Delta River-Black Rapids area
4.	Well drained brown gravelly soils of low slopes, well drained brown gravelly soils of steep slopes.	23 28	8. 10	Delta River area Little Tonsina-Tiekel River area
5.	Well drained gravelly brown soils in association with well drained gravelly soils	4	1	Willow Mtn. area
6.	Well drained thin gravelly soils w/dark surface layer in association w/rockland	23	8.	Tiekel River Valley
7.	Rockland	27	10.	Alaska & Chugach Ranges
8.	Well drained gravelly acid soils in association with poorly drained loamy soils having an overlying.	47	17.	South slopes, Alaska Range
9.	Well drained gravelly acid soils w/dark subsoil in association w/peat	31	11.	Area bordering Prince William Sound
	Totals	285	100	

more years. Refer to Figures 8.2.1-13a and 13b for reference to the permafrost areas relating to this alternative route.

In northern Alaska, permafrost forms a virtually continuous layer to a depth of several hundred feet beneath the surface. It reaches a maximum thickness of about 2,000 feet in the vicinity of Prudhoe Bay (Howitt and Clegg, 1970). Distribution and thickness depends on the local glacial and climatic history, the thermal properties of the local sediment and rock, and the insulating properties and thermal balance of material at the ground surface. In the zone of continuous permafrost, ground ice is present only where soils are wet.

The factors that control the distribution of permafrost also control its temperature, which varies markedly with depth, latitude, and geologic and topographic setting. Permafrost temperatures are especially affected by large, deep rivers and lakes. Heat from these water bodies tends to increase the temperature of permafrost in adjacent areas. In the lowland area north of the Brooks Range, the temperature of permafrost at depths just below the zone of seasonal variation generally ranges from -11° to -5°C (about 12° to 23°F). Within mountainous areas, permafrost temperatures are extremely variable.

Even in the coldest parts of Alaska a thin layer of ground, the active layer, thaws every summer and separates the permafrost from the ground surface. The thickness of the active layer depends on the capacity of the surface material to protect the underlying permafrost from summer heat. The thickness can vary locally from 1/2 foot to 5 or more feet and can change dramatically when the surface is disturbed.

Within the Arctic Coastal Plain division, the entire land area is underlain by permafrost at least 1,000 feet thick, and in the Prudhoe Bay area it is as much as 2,000 feet thick (Howitt and Clegg, 1970). The permafrost table is 1/2 to 4 feet below the ground surface, except beneath the major rivers where it is deeper. A network of polygons covers most of the coastal plain. The outer edges of these polygons mark the surface expression of buried ice-wedges. They are oriented parallel and perpendicular to receding shorelines because of stress differences set up by horizontal temperature gradients. Random ploygons form in areas of more uniform stress. Near Prudhoe Bay, permafrost is reported to extend offshore beneath the waters of the Beaufort Sea to at least the barrier islands.

Soils encountered along the route in the Coastal Plain are extremely ice-rich silt and fine sand overlying frozen sand and gravel. Massive and interstitial ice forms occur throughout the 5-15 foot thick silt mantle and fine sand mantle, but in the underlying several hundred feet of sand and gravel the ice generally occurs as coatings on clasts and as void fillings.

Massive ice forms and extensive interstitial ice are common in the silty soils in the Arctic foothills and rare in flood plain sand and gravel, but do occur in the silty soils of low terraces of sand and gravel.

The entire province is underlain by continuous permafrost. Ice wedges, stone stripes, and polygonal ground, features of a frost climate are common.

Within the Brooks Range some unconsolidated deposits are ice-rich, especially the silt and clay-rich tills. Ground ice in the form of beds and lenses up to a foot or two thick is probably present in the moraines. Bedrock is free of ground ice, although its temperature is almost always below freezing.

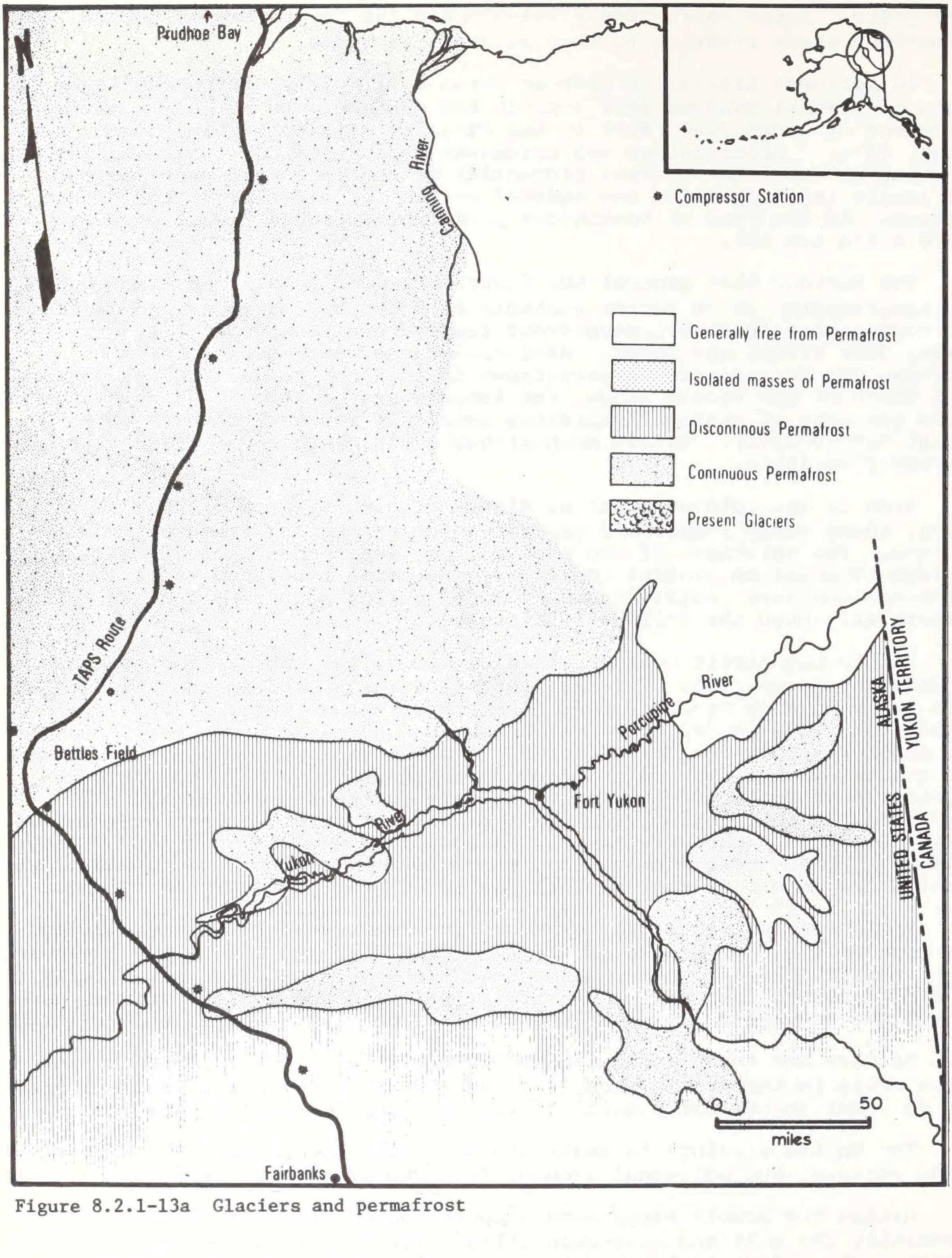


Figure 8.2.1-13a Glaciers and permafrost

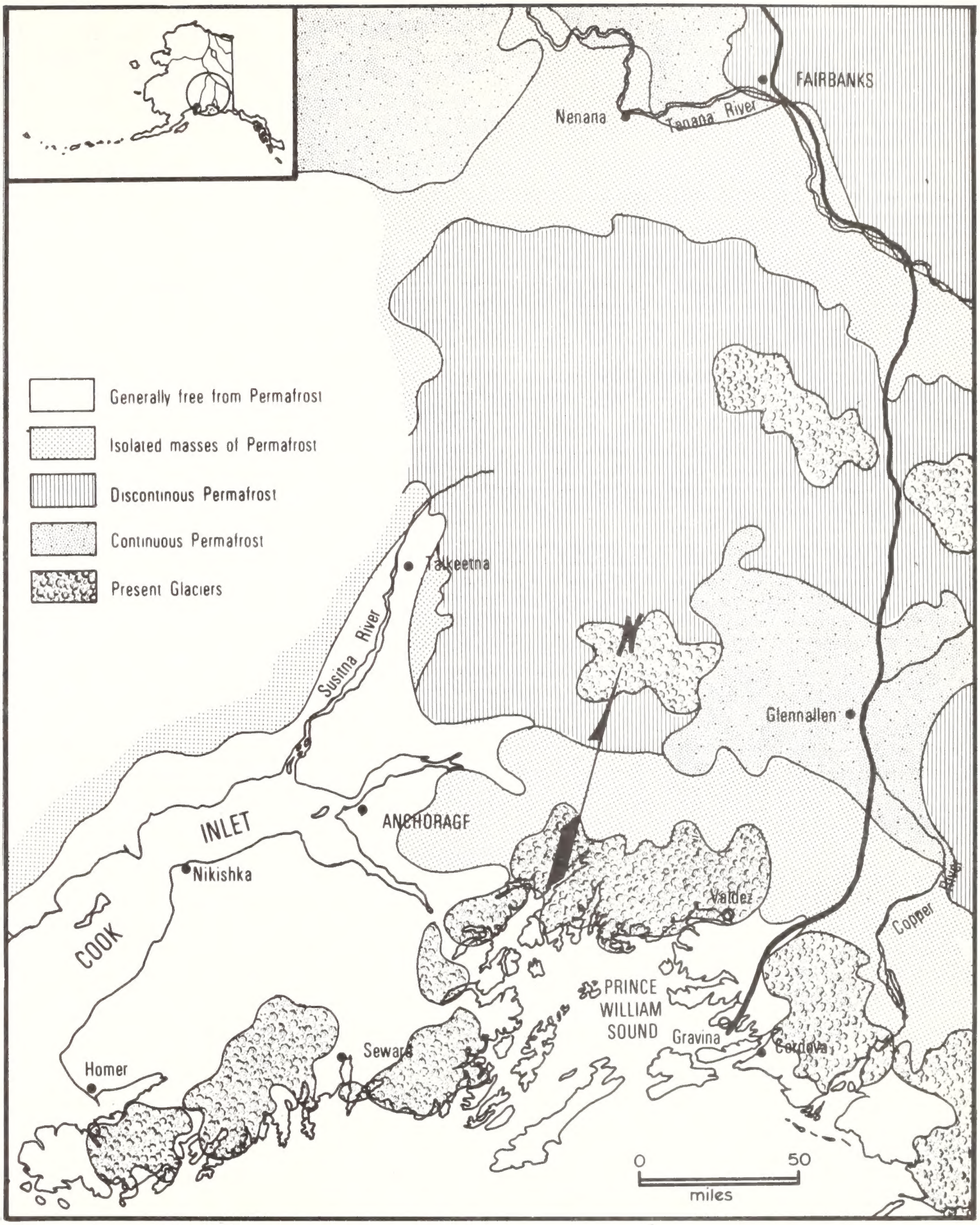


Figure 8.2.1-13b Glaciers and permafrost

Geologic units to be traversed include frozen ice-rich silts over alluvial gravels from Shaw Creek across the Shaw Creek Flats, frozen silt (loess) over bedrock (schist) from the southern end of Shaw Creek Flats to the Tanana River, and generally thawed gravels and sands of alluvial origin from the Tanana River to south of Fort Greely. Permafrost is essentially continuous from Shaw Creek to the Tanana River.

In the frozen zones ice forms include interstitial ice, massive lenses, and ice wedges in the surficial deposits overlying either bedrock or the alluvial gravels.

Permafrost is essentially discontinuous from the Tanana River south through the Alaska Range. In the frozen zones ice forms include interstitial ice, massive lenses, and ice wedges in the surficial deposits overlying either bedrock or the alluvial gravels.

Permafrost is essentially continuous, except in the valleys of the major rivers from the north end of the Copper River Basin to the Klutina River. Locally, south of the Klutina River the top of the permafrost is more than 30 feet below the surface. The plastic glaciolacustrine soils in general are dense and contain ice in the form of veins and veinlets. This condition is believed common throughout the basin except where massive ground ice is present.

Ice-rich permafrost generally is not present in the southern end of the route, except for between Willow Lake and the Little Tonsina River, where fine-grained soils locally are ice-rich.

Erosion and Mass Wasting--The primary environment of erosion along the proposed pipeline route is at the major river crossings. Erosion is concentrated during the peak runoff periods of late spring and early summer as the water in the channels shifts from bank to bank, widening and forming new channels and scouring the channel floors. The buildup of ice at certain locations along the river during the winter (aufeis) can produce local flooding and significant channel shifts. During the winter water caused erosion is almost nonexistent.

Of lesser importance in terms of volume of erosive products is gullying on hill slopes. This occurs where removal of the organic mat by man or natural processes such as mass wasting or fire has exposed the underlying ice-rich sediments. When permafrost melts at these localities, the original small scar becomes the site of increased erosion and gullying as rain and melt water is channeled into the newly formed gully.

In the Coastal Plain and Foothills, flooding, erosion, and aufeis occur along the Sagavanirktok River.

Within the Brooks Range aufeis is extensive, reaching thicknesses of 12 to 15 feet; single fields may be up to 3 or 4 miles. Aufeis buildup occurs throughout interior Alaska. The buildup of ice is often a warning of existing or potential erosional problem. Erosional problems are unavoidable on steep slopes and at river crossings.

Within the Arctic Coastal Plain, slopes are flat to gently sloping and mass wasting features are few. Summer melting of ice-rich silt results in periodic cave-off and slumping of the steep river and lake banks. Soil and organic mat-creep and solifluction may result in very slow and shallow movement of surficial materials.

In the Arctic Foothills, the ice-rich, silt-covered slopes are sufficiently steep to produce mudflows, small landslides and a widespread solifluction mantle. Where the organic mat insulative cover has been stripped, either naturally by mass wasting or artificially by man, vivid scars are evident on the landscape. Deep melting of the underlying exposed ice-rich sediments results in the development of small lakes in gently sloping areas and deeply eroded valleys (up to 20 feet deep) on steeper slopes. Except on the steeper valley slopes mudflows and landslides are rare in the Foothills area.

In the Brooks Range, valley walls are steep and talus and rock falls are prevalent. A few earth flows, mudflows, soil slips, and landslides are present on the steep slopes underlain by glacial silt. In the divide area of the Brooks Range, talus and block rubble deposits are common on the sides and at the bases of the steep valleys.

Seismicity--The level of seismic activity along the northern portion of this alternative route is relatively low.

The seismic history along this portion of the route is short relative to the time over which strains accumulate to produce an earthquake; hence, the historic record of seismicity is a limited guide to future seismic risk.

The earthquake potential along the northern portion of this route may be specified in terms of a maximum expectable earthquake of magnitude 5.5. This is consistent with the use of a magnitude 5.5 design earthquake for the northernmost segment of the trans-Alaska oil pipeline. The largest known earthquake north of 67° N latitude is magnitude 4.7 on the Richter Scale.

From 67° N south to Donnelly Dome, the activity is relatively high. In July 1937, a magnitude 7.3 earthquake occurred southeast of Fairbanks. Landslides, mud boils, and ground fissures were observed (Bramhall, 1938) within 10 miles of the route. On June 21, 1967, series of three magnitude 5.5 shocks occurred within a few miles of the route (Gedney and Berg, 1969). Surface faulting was not observed in either earthquake episode. In this section of the route, the seismic risk is substantial, although it cannot be correlated with recognizable tectonic features.

In October 1968, a magnitude 6.5 earthquake north of Fairbanks caused extensive landsliding and ground breakage within 30 miles of the route. Aftershock epicenters were located within 15 miles of the route (Gedney and others, 1969).

Hundreds of epicenters for small earthquakes recorded during recent years with the regional seismograph network operated by the University of Alaska delineate active seismic zones that transect the route.

Focal depths earthquakes in the vicinity of the route, though not everywhere precisely determined, place all the earthquakes in the crust. Accordingly, there is no a priori reason to expect that larger earthquakes along the route will not rupture the surface.

Between Donnely Dome and Paxson, the route crosses the Denali fault along which there is abundant geologic evidence of large, predominantly lateral Holocene offsets (Richter and Matson, 1971; Stout and others, 1973). No major earthquake has been positively identified with the Denali fault in this century; however, seismic quiescence is observed elsewhere on major faults that have generated large historic earthquakes and is inferred to correspond to a phase of behavior where the fault is locked and strains are accumulating for a future release. The geologic and geophysical evidence suggests that sometime in the future large earthquakes accompanied by large surface displacements will occur on the Denali fault. An earthquake as large as magnitude 8.0 is postulated for the Denali fault system (Page and others, 1972). A fault offset of at least 20 feet could be expected for such an event. From Paxson to Willow Lake, the known historic seismicity is relatively low with no earthquake as large as magnitude 6.0 recorded within 50 miles of the route. The seismic potential is not considered as low, however, because this segment lies between two regions of high seismic risk where earthquakes in the magnitude 8 class can be expected.

South of Willow Lake, the earthquake potential is extreme as demonstrated by the great (magnitude 8.5) 1964 earthquake, destruction from which caused the city of Valdez to be relocated. The 1964 shock was one of the largest earthquakes ever recorded. The earthquake and the resulting seismic sea waves killed 114 people and caused over $300 million of damage in Alaska and along the coast of British Columbia and the western conterminous United States. Uplift and subsidence as large as 38 feet and 7 1/2 feet respectively were measured, and permanent vertical deformation of the ground was observed over an area of 70,000 square miles (Plafker, 1969). A recent detailed study of seismicity in the vicinity of Valdez shows that seismic activity is currently concentrated west and north of Valdez with much activity around Jack Bay (Page and others, 1974). Similar detailed studies of seismicity have not been undertaken in the vicinity of Gravina Point (+-39 mi [62 Km] from Valdez) and Cordova. In the absence of better knowledge, the seismic hazard is judged to be comparable for Gravina Point, Jack Bay, and Cordova.

The area near the little Tonsina River was subjected to ground breakage and landsliding during the M 8.4-8.6 1964 earthquake (Ferrians, 1966) which had its epicenter about 70 miles west of the route.

The earthquake potential along the route has been expressed in terms of the maximum expectable earthquake (USDOI, 1974), as follows:

Beaufort Sea to 67° N	5.5
67° N latitude to Donnelly Dome	7.5
Donnelly Dome to Paxson	8.0
Paxson to Willow Lake	7.0
Willow Lake to Valdez (Gravina Point)	8.5

Water Resources

Surface Water--Sagavanirktok River Drainage--This alternative route is located in close proximity to the west bank of the Sagavanirktok River, and crosses the Putuligayuk and the headwater areas of the Colville and Kuparuk River drainages.

Streamflow records are published by the U.S. Geological Survey in cooperation with the State of Alaska on the Putuligayuk River, the Kuparuk River, and the Sagavanirktok River. Flow of streams in the Arctic Slope Drainage is dominated by high flow in spring, a gradual decrease throughout the summer, and a virtual cessation of flow during winter months.

All streams have water of good quality which is acceptable for most uses. The pH of streams is generally above 7.0 but in some glacier-fed streams falls between 6.0 and 7.0. The amounts of sediment load varies widely from stream to stream and in time during the year. The major discharge of sediment occurs at breakup when most of the sediment for the year is carried. Conductivity during summer generally ranges from 100 to

300 micromhos/cm. During winter, flows generally decrease, and as more water comes from groundwater storage in the banks of streams conductivity increases.

Dissolved solids content of waters generally averages less than 200 milligrams per liter (mg/l) and no appreciable amount of iron is present in the waters sampled. All of the waters are of the calcium bicarbonate type and would be acceptable for most uses.

Lakes generally reflect the same types of waters as do the streams in the area. Deeper lakes, 7 feet or more, do not freeze to the bottom during winter. Waters in the deeper lakes from which water is drawn throughout the year show definite increase in conductivity as winter progresses. Color from organic sources is generally higher in lakes than in streams. Most of the water not in proximity with the ocean is of the calcium bicarbonate type.

Yukon River Drainage--The corridor crosses the drainage basins of the North and South Forks of the Koyukuk River, Kanuti River, Hess Creek, Tolovana River, Chatanika River, Chena River, Salcha River, Tanana River and Delta River.

Streamflow records are published by the U.S. Geological Survey in cooperation with the State of Alaska for the Koyukuk River, Hess Creek, Chatanika River, Chena River, Salcha River and the Tanana River.

Flow of streams in the Yukon drainage varies considerably from north to south. Streams north of the Yukon River often freeze to the bottom over most of their width. The build up of ice cause streams to overflow and ice to build up also on the flood plains of the streams.

Water quality data are rather limited in the drainage. A considerable amount of data near Fairbanks suggested a general range of dissolved solids of 200 to 300 mg/l. Most streams and lakes in the drainage have pH values higher than 7.0. Water is generally calcium bicarbonate type.

Copper River Drainage--The route parallels the Gulkana River and crosses the Tazlina, Klutina, Tonsina, and Tickel River drainages. Streamflow records are published by the U.S. Geological Survey in cooperation with the State of Alaska on the Tazlina River near Glennallen.

Most of the streams in the area are glacier fed and are dominated by high flows from spring breakup through early fall. Peak flows in most of these streams occurs in late summer or early fall; flows generally diminish during the winter. The Tazlina and its tributaries are considered susceptible to glacial outburst flooding.

Stream water quality is generally good throughout the area. Most of the waters in the area contain glacial silt but are generally of the calcium bicarbonate type, with pH values higher than 7.0, and having conductivity ranges from about 150 to 300 mhos. Lakes in the area generally reflect similar water quality.

Prince William Sound Drainages--The route parallels the Lower River and crosses it and the Gravina River. Streamflow records are published by the U.S. Geological Survey in cooperation with the State of Alaska on several of the smaller streams in the Prince William Sound Drainage but not those crossed by the pipeline.

Streamflow in the area is dominated by high flows which last from ice breakup through fall. High flows occur in the spring with the breakup of ice and increase with peak flows coming in late summer or early fall; by November streamflows lessen and generally reach a minimum by March. Most streams in the area are glacier fed and show a rapid response to summer and fall rain falls.

Stream water quality in the area is generally good with low values for conductivity, pH values higher than 7.0, little or no iron content, and only moderate amounts of sediments in the glacial streams and little or none in the non-glacial streams. Lakes in the area are believed to have similar water quality. Most of the waters are calcium or sodium bicarbonate type waters which are acceptable for most uses.

Ground Water--Aquifer systems within the State of Alaska are apparently not widespread. Water movement is controlled throughout the State by the geologic structures and movement of water is down stream valley systems.

On the Arctic Coastal Plain and on both slopes of the Brooks Range permafrost exists to a considerable depth. For this reason there is relatively little ground water movement in the area. Such movement as is known to exist is generally found in alluvial aquifers associated with streams. The quality of this ground water generally reflects the quality of water in the streams. Springs and a limited number of shallow ground water sources also exist. There is little data pertinent to the Prudhoe-Gravina corridor.

Ground water in the northern portion of the Yukon Drainage is very similar in quality to that found in the Arctic Drainage. Near the Yukon River where permafrost is discontinuous, water quality can be characterized as ranging from good to poor, alkaline, moderately hard to hard, and of a calcium bircarbonate type. Near Fairbanks and near most of the streams in the area, waters can have high iron content, and often high manganese content.

Ground water in the Copper River Drainage is good quality from shallow wells and of the calcium bicarbonate type, with hardness range of 200 to 400 mg/l. Water from deeper wells in the area commonly are saline with high dissolved solids concentrations.

Ground waters in the Prince William Sound Drainage are generally of good quality, either calcium or sodium bicarbonate type, alkaline, with a hardness range of from 100 to 150 mg/l. Deeper wells in coastal areas may obtain waters high in chloride or sulfate content.

Water Use--There is no present use of ground water along the northern part of this route where continuous permafrost exists. Future use will tap the alluvial aquifers under larger streams.

None of the streams along this route are utilized as municipal supply sources either through reservoirs or through other bodies of water connected to the streams. Water may be drawn from streams by local residents for domestic use and by individual hunters or fishermen at certain times of the year however.

Little or no uses are made of ground water in the Arctic Drainage system or in the northern portion of the Yukon Drainage system. Near Fairbanks considerable use is made of well waters both by individuals and communities. The City of Fairbanks obtains its water supplies from wells, as do nearby military bases.

Principal aquifers being tapped for ground water supplies throughout the area are the alluvial and glacial aquifers. Most of these lie near streams where recharge is directly from streams.

No data are available on recharge rates in the areas in which ground water is utilized.

Hydrologic Hazards--Ice jams and flooding may occur in major rivers in Alaska in the spring, since river ice (usually several feet thick) does not always break up uniformly and may accumulate in unfrozen reaches in areas of constriction, or in the shallows.

Channel scour, shifting of stream channels, and lateral erosion occur continuously throughout a flood plain, but may be accelerated greatly by icings or ice-jam flooding. Major floods, including outburst floods from glacier lakes, may cause channel scour and subsequent deposition to unusual depths. In many streams, bed materials are more resistant to scour than are bank areas, especially when the beds are protected by a channel armor layer. This is especially true in meandering streams. During floods, water tends to erode upstream-facing margins of meanders and deposit materials on the opposite margins. Occasionally, flows breach the necks of meanders and form new channels.

Ice jam flooding is generally restricted to larger streams such as the Yukon or Tanana Rivers. To the south near the Alaska Range the proposed pipeline route passes near small glacier-dammed lakes which have potential for outburst flooding.

Black Rapids, Castner, Canwell, and Fels glaciers all terminate in the segment north of the Alaska Range. During the winter of 1936-37, Black Rapids Glacier advanced rapidly for a distance of more than 4 miles (Hance, 1937; Moffit, 1942). The rate of advance averaged over 200 feet a day.

The flows of the Lowe, Tsaina, Tiekel, Tonsina, Klutina, Tazlina, and Gulkana Rivers, all to be crossed by this alternative route are affected by glacier runoff.

Along the Tsaina River canyon northeast of Thompson Pass, through which the route crosses the Chugach Mountains, glacier termini generally lie between 3,000 and 4,000 feet altitude. Exceptions are the Tsaina Glacier (two lobes) and Worthington Glacier, which terminate between 2,200 and 2,300 feet altitude. Inspection of aerial photographs indicates that the Worthington Glacier has been receding in the recent past. At least four terminal moraines can be distinguished west of the Richardson Highway.

Several existing glacier-dammed lakes in the Chugach Mountains are in drainage basins that would be crossed by the alternative route. The two large lakes occupy ice-free tributary valleys of the Tazlina Glacier. Two more lakes are dammed by the Nelchina Glacier. The meltwaters from both Tazlina and Nelchina Glaciers empty into Tazlina Lake before flowing into Tazlina River.

At the U.S. Geological Survey streamgaging station at the Richardson Highway crossing of the Tazlina River, about 45 miles downstream from the outlet of Tazlina Lake, fifteen peak discharge attributed to icedam breakouts have been recorded since 1950. Occurrences in four years are shown in the following table:

Flow of Tazlina River attributed to ice-dam breakouts. Data from U.S. Geological Survey.

August 1962

Date	MDF (in cfs)*
10	19,900
11	23,500
12	27,800
13	40,600
14	55,400
15	46,800
16	35,700
17	30,000
18	25,100

August 1965

Date	MDF (in cfs)
13	11,500
14	13,300
15	17,200
16	24,300
17	41,100
18	37,900
19	28,600
20	24,500
21	21,100

July-August 1966

Date	MDF (in cfs)
25	14,100
26	15,100
27	17,700
28	24,200
29	25,300
30	23,200
31	23,000
Aug 1	22,800
2	22,300
3	21,700
4	20,600
5	19,400

July-August 1968

Date	MDF (in cfs)*
Jul 26	17,400
27	18,900
28	23,100
29	31,900
30	48,000
31	45,700
Aug 1	40,400
2	39,500
3	33,900
4	28,000
5	22,800

*MDF = mean daily flow cfs = cubic feet per second

Vegetation

Major Plant Formations, Associations, and Communities--The proposed natural gas pipeline from Prudhoe Bay to Gravina Point would pass through three major vegetative divisions in Alaska. They are the Arctic Drainage Division which runs from the Brooks Range northward to the Arctic Ocean, the Interior Basin Division which runs from the Chugach Mountains in southern Alaska northward to the Brooks Range, and the South Coastal Division which covers the area south of the Chugach Mountains to the Gulf of Alaska. The Interior Basin Division is by far the largest of the three in the area.

The Arctic Drainage is dominated by tundra. It is an area dotted with lakes and cut by streams. By definition, tundra means a treeless plain, in the sense that no tall trees would be encountered. There are trees in the tundra, but they are dwarf varieties of willow and birch. Floodplain thickets occur along rivers on newly exposed alluvial deposits. The dominant vegetation types are willow and alder which reach heights of 5 to 10 feet. The types of vegetation found in the tundra are only those species which can withstand constant disturbance of the soil, buffeting by the wind, and abrasion from wind-carried particles of soil and ice. These types include herb shrubs, sedges, rushes, herbs, mosses and lichens.

The Interior Basin is characterized by a patchwork of grasses, shrubs, broad-leaved deciduous trees, and spruce forests. This variation is caused by differences in exposure, surficial deposits, topography, depth to permafrost, and fires. In areas of poor drainage, low marshy areas are found.

The third division and the smallest, the South Coastal, is the most biologically productive of the three. This is the result of abundant moisture, high humidity and warm temperatures caused by the Alaskan Current, which flows along the coastline. Thick forests of Sitka spruce and western hemlock pervade the area.

Within these three vegetative divisions are found six vegetation types as described below and shown in Figure 8.2.1-14a and 14b.

Alpine Tundra--Alpine tundra constitutes 23 percent of Alaska's land surface. It is found in all of the mountain ranges and on exposed ridges in the Arctic and southwestern coastal areas. White mountain-avens which cover entire ridges and slopes with a mat of vegetation dominate in this area where plant growth is found interspersed between bare rocks and rubble. Associated mat-forming herbs include moss-campion, black oxytrope, arctic sandwort, and several grasses and sedges. Low heath shrubs such as cassiopes and mountain heaths are the most important plants in the southeastern coastal mountains and the Aleutians.

Moist Tundra--This vegetation type forms a complete ground cover and is extremely productive during the summer season. It varies in composition from almost continuous and uniformly developed cottongrass tussocks with limited amounts of other sedges and dwarf shrubs to stands where dwarf shrubs are the dominant vegetation. The cottongrass tussock vegetation is the most common type in Arctic Alaska.

Wet Tundra--As its name implies, this type has standing water present in the summer. Permafrost is close to the surface in the more northern regions. Sedges and cottongrass are the dominant vegetation in this area. A vegetation mat is formed by these two plants instead of tussocks as is found in moist tundra. Other vegetation found here include lichens, mosses, low-growing willows, dwarf birch, Labrador tea, cinquefoil, and beach rye. Burn weed, pond weed, perdent grasses and mare's tail are rooted aquatic plants also found in the area.

Open, Low-Growing Spruce Forests and Treeless Bogs--This vegetation type is the second component of the Interior Basin Division. Black spruce forests dominate north-facing slopes and poorly drained lowlands. This area is usually underlain by permafrost. The understory is made up of a thick moss mat, usually of sphagnum mosses, sedges, grasses, and heath. Also found along with black spruce are stands of tamarack.

In areas where excessive moisture prevents tree growth, large bogs are found. The vegetation growing here includes sedges, mosses, bog rosemary, resin birch, dwarf Arctic Birch, Labrador tea, willow, cranberry, and blueberry. Floodplain thickets are found in the interior along newly formed alluvial deposits which are periodically flooded. Vegetation found there includes alder, dogwood, silverberry, rose willow, and high bushcranberry. Birch-alder-willow thickets occur near the treeline in interior Alaska and beyond the treeline in extensive areas of the Alaska and Seward peninsulas. It is composed of resin birch, alder, and several willow species. The willow species prefer the drier or wind exposed areas, the birch on mesic sites, and the alder on the wettest sites.

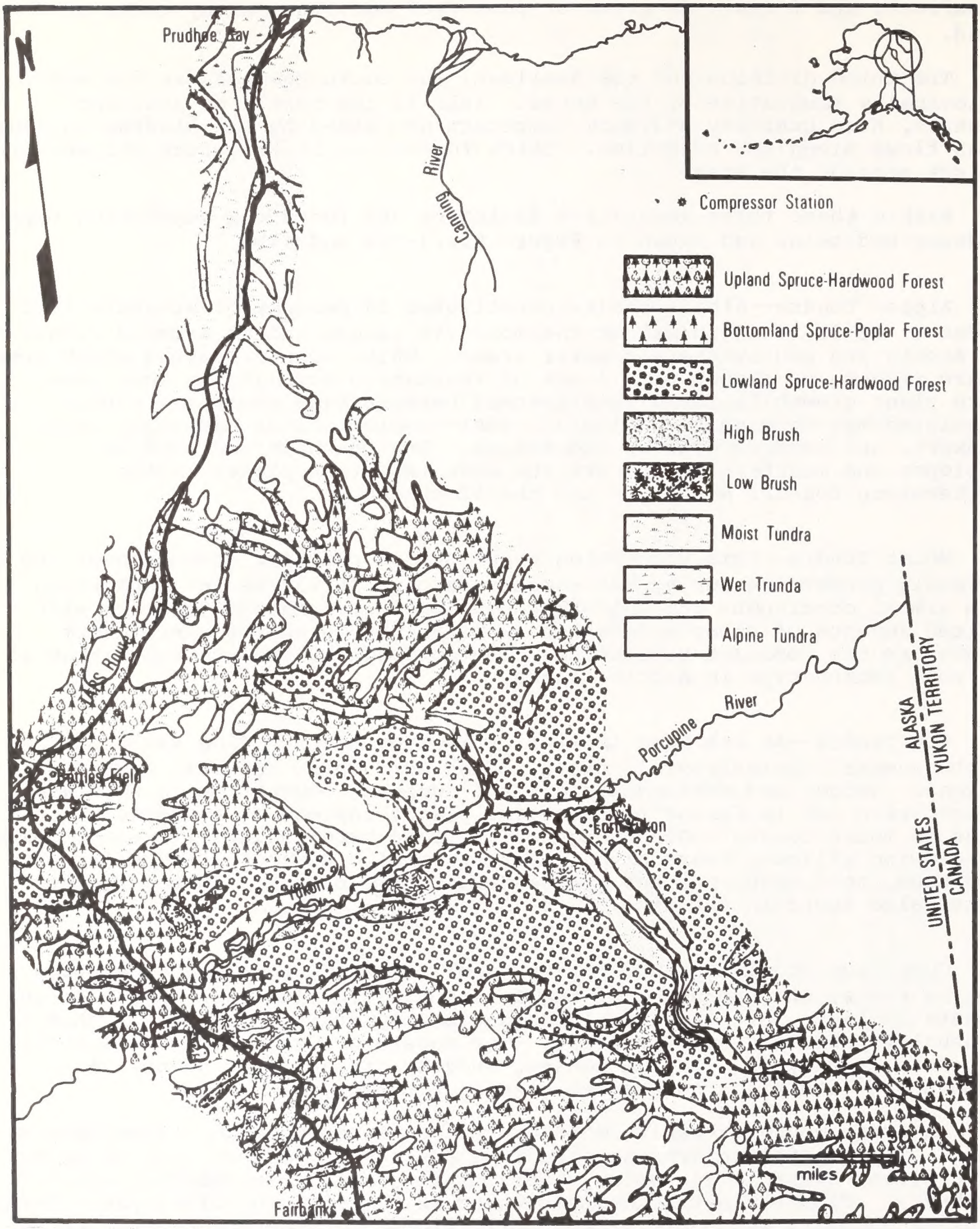


Figure 8.2.1-14a Generalized land ecosystems

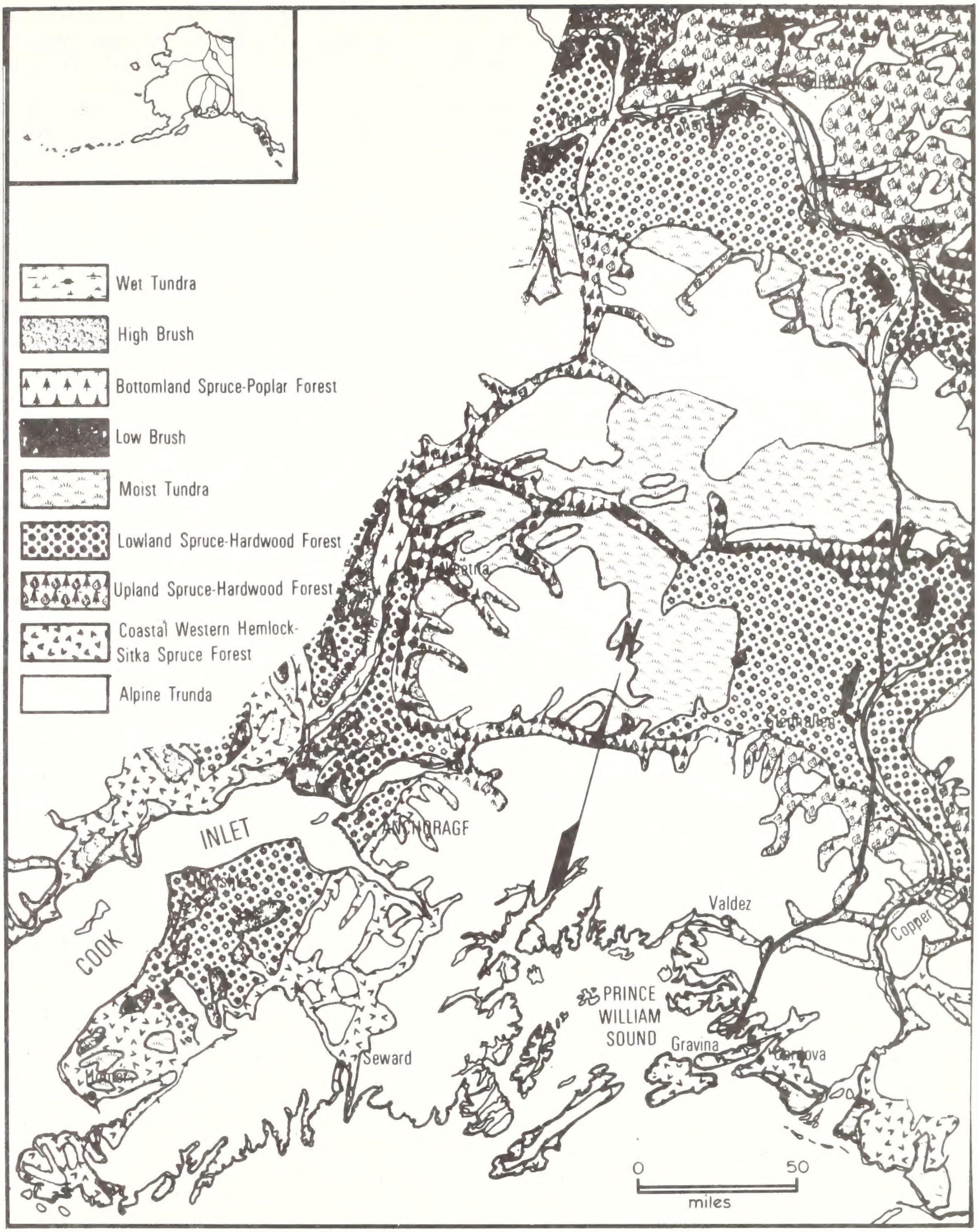


Figure 8.2.1-14b Generalized land ecosystems

Closed Spruce-Hardwood Forests--The vegetation in interior Alaska is greatly affected by fire, which leads to a patchwork of vegetation types throughout the region because of the many local areas in different stages of succession. The first stage after a fire is generally made up of light-seeded willows. Fast growing aspen then begins to dominate on upland south-facing slopes for 60 to 80 years after which it is replaced by white spruce. On east-west facing slopes paper birch is the first invading tree species. The white spruce stands are open under the canopy and contain an understory composed of rose, alder, ferns, high and low bush-cranberry, raspberry, current, and horsetail.

Coastal Spruce-Hemlock Forests--This vegetation type comprises approximately 6 percent of Alaska's land area. The coastal forests are composed mainly of western hemlock and Sitka spruce with a scattering of mountain hemlock, western red cedar, and Alaska cedar. Red alder is found along streams, beach fringes, and on soils recently disturbed by logging and landslides. Shrubs such as blueberry, huckleberry, copperbrush, devilsclub, and salal are prominent in the area. Mosses grow profusely on fallen logs, on lower branches of trees, and in forest openings.

In areas of poor drainage, a treeless vegetation is found which is called muskeg. It is composed of a thick sphagnum moss mat with sedges, rushes, low shrubs, and fruticose lichens. In addition to muskeg, dense alder thickets are found in the spruce-hemlock forests. It is also found between the beach and the forest, between the treeline and the alpine tundra meadows, and extending from treeline downward through the forest in avalanche tracks, and along streambanks. Beneath the alders there is often a well-developed grass and fern layer, as well as a number of herbs and shrubs.

Human Influences on Existing Vegetation--Before the arrival of European civilization in Alaska, human impact on the vegetation was minimal. Native Alaskan peoples lived in close harmony with the natural environment. There were no attempts to modify the existing environment to better suit their needs. If food was plentiful they prospered; if scarce, they starved. Examples of remnants of their impact consist of abandoned villages and stone guide markers on the tundra.

Since the arrival of the white man, the impact on the vegetation has been rapidly increasing as Alaska's natural resources are utilized. The search for gold and the recent rush for oil drew thousands of men into the wilderness of Alaska. Their disregard for the fragile nature of the tundra and arctic environment has left scars which will last for years or even centuries. One example is the now classic story of the tracks across the tundra made by one horse drawn wagon that are still visible 50 years later.

Unique, Sensitive, and/or Threatened Ecosystems--Much has already been said in various other publications on the fragile nature of the vegetative ecosystems of Alaska. But this fact must be re-emphasized due to the uniqueness of the area. The low productivity and slow regenerative powers of the vegetation in most of Alaska amplify the time intervals needed for re-vegetation. Trees in temperate regions that take 15 years to reach a height of 10 feet need 100 years in the Arctic to reach the same size. Lichen, a large part of the diet of caribou, grow at a rate of only 4 millimeters per year. It is this extended time frame that poses one of the major problems in understanding the Alaskan vegetation. In addition, Alaska is one of the few remaining regions in the world where ecosystems relatively untouched by man can be found. The importance of these areas for scientific study and for use as a benchmark to compare the effects of man's disturbance on other ecosystems cannot be overemphasized.

Threatened Species--The Smithsonian Institution, under the Endangered Species Act of 1973, has prepared a list of endangered and threatened plant species in the United States, which includes thirty species found in Alaska. This report to Congress is being reviewed by the Secretary of the Interior (Federal Register Tuesday, July 1, 1975, volume 40, number 127). No survey has been made to determine which, if any, of these endangered and threatened plant species lie along the proposed route.

Fire: Incidence and Characteristics--Surface layers may be burned during dry periods producing longlasting changes in plant composition. While authors have variously regarded fire as a destructive or beneficial force (e.g., Lutz, 1956; Slaughter, et al., 1971; Rowe and Scotter, 1973; Viereck, 1973; Strang, 1973), it is now recognized as a rejuvenating force in the boreal forest.

Fire opens the forest canopy, creating areas for colonization by species with seedlings or suckers adapted to growing on sites where full light intensity reaches the ground. Rowe (1970) discussed the fire ecology of black and white spruce in the northern Boreal forest. Zasada (1971) discussed the natural regeneration - i.e., seed production and dispersal, seedbed requirements, seedling viability, and vegetative reproduction - of the five major tree species: black spruce, white spruce, paper birch, quaking aspen, and balsam poplar.

Fire does not occur at the same time everywhere in the boreal forest. Natural barriers--lakes, mountains, rainstorms, changes in wind--extinguish or confine fires. The result is a mosaic of plant communities of different ages, species, and successional stages (Shaft and Yarranton, 1973). This mixture of diverse communities within a wide area can respond to fire as a force in the natural environment, since plants and animals that could colonize burned areas are present nearby.

Occasionally, extensive areas (thousands of square miles) are burned at the same time. The result is a major change in vegetation from mature to successional communities and, with this, a change in animal populations.

Initially, fires in permafrost areas cause increased thaw. This results in subsidence in proportion to the volume of melted ice and the evaporation of water (Mckay, 1970). Slumping and erosion can also occur where excess ice is present. In recent years these effects have resulted largely from attempts at fighting fires and not from the fires themselves. Bulldozing of fire guards and fire breaks in interior Alaska increased stream turbidity for several years after the fire (Lotspeich and Mueller, 1971). Erosion of fire breaks in interior Alaska resulted in gullies 20 to 30 feet (6 to 9 m) deep in just two years, an erosion problem much greater than that created by the fire proper (DeLeonardis, 1971).

Fire Relations in the Northern Boreal Forest and Forest-Tundra--Wildfires in the taiga and tundra of interior Alaska are, and probably always have been, integral dynamic processes of ecosystem functioning. Fire ecology in this region has been reviewed by Lutz (1956), Barney (1971a), Slaughter, et al., (1971), and Viereck (1973). The natural ecological role of fires is:

Fire acts as a by-pass of the decomposition process, which is limited in the Interior by dry and cool conditions that inhibit microbial activity and as an important agent for recycling essential nutrients that otherwise become tied up in dead organic materials, such as litter, standing dead plants, and peat accumulations.

It also acts as a natural disruptive force that prevents succession of vegetative communities to a climax type, with its impoverished diversity in structure and species numbers.

Thus, fire is essential to ecotone, or "habitat edge," development which enhances both primary and secondary (i.e., wildlife) productivity.

This modern appreciation of wildfire ecology is necessary, but not sufficient, to form an understanding of the dynamics of fire in interior Alaska. Agents of ignition, fuel type, fuel load, climate, weather, and past fire history all influence the probability of wildfire and the intensity of a burn.

Fire History in the Northern Boreal Forest and Forest-Tundra--Much of the available historical information on the occurrence of fire in northern regions (Canada, Alaska, Eurasia, Scandinavia) is cited by Lutz (1956:10-17). Lutz (1959) discussed the importance of man in causing fires. Many small fires lit for a variery of reasons escaped to burn forests (Lutz, 1959). Large areas were also deliberately burned. During the gold rush at the turn of the century in the Yukon and Alaska, the hills were deforested by fires set on purpose to ease access to bedrock. Timber was also cut and burned to thaw the frozen ground in order to facilitate the extraction of gold (Berton, 1972).

Fire statistics have been recorded in Alaska since 1940. Man caused 71 percent of all reported fires but these accounted for only 38 percent of the total area burned during 1950-1959. During the 1960's, the corresponding values were 64 percent and 28 percent respectively (Barney, 1971b). An average of 982,000 acres have burned per year in interior Alaska during the past 30 years out of a total of 120,000,000 acres of forest (Lutz, 1956). The range of values, however, has been from 3,400 acres in 1964 and 5,050,000 acres in 1957. Alaskan experience indicates that the number of fires reported has increase in the past 30 years but the total area burned has decreased. Barney (1971a) believes this has resulted most likely from improved fire detection and more aggressive fire suppression policies.

Bureau of Land Management records for the period 1965 through 1974 show the highly fire-prone area south of 68 North latitude has had 4,700 fires, an average of 470 fires per year.

Wildlife

The wildlife along this alternative route will be discussed by drainages. There are 4: Arctic Slope (Tundra), Yukon and Copper (interior forest), and Lowe (ends in coastal forest). Once an animal has been discussed in detail it will not appear again except in the general discussion for the drainage. Refer to Table 8.2.1-6 for mammals, Table 8.2.1-7 for birds and Table 8.2.1-8 for fish.

Table 8.2.1-6 Mammals found along the route of the trans-Alaska alternative

	SAGAVANIRKTOK DRAINAGE	YUKON DRAINAGE	COPPER DRAINAGE	LOWE DRAINAGE
Masked shrew	x	x	x	x
Tundra shrew	x	x		
Dusky shrew	x	x	x	x
Pygmy shrew		x		x
Little brown myotis			x	x
Collared pika		x	x	
Arctic hare	x			
Snowshoe hare		x	x	x
Woodchuck		x		
Hoary marmot	x	x	x	x
Arctic ground squirrel	x	x	x	x
Red squirrel		x	x	x
Northern flying squirrel		x		
Beaver		x	x	x
Greenland collared lemming	x	x		
Northern bog lemming		x	x	x
Brown lemming	x	x	x	x
Red-backed vole	x	x	x	x
Meadow vole		x	x	
Long-tailed vole		x		
Yellow-cheeked vole		x		
Tundra vole	x	x	x	x
Alaska (Singing) vole	x	x	x	x
Muskrat		x	x	x
Porcupine		x	x	x
Coyote	x	x	x	x
Gray wolf	x	x	x	x
Arctic fox	x	x	x	x
Red fox	x	x	x	x
Black bear		x	x	x
Grizzly/Brown bear	x	x	x	x
Polar bear	x			
Marten		x	x	x
Short-tailed weasel	x	x	x	x
Least weasel	x	x		
Mink	x	x	x	x
Wolverine	x	x	x	x
River otter	x	x	x	x
Lynx	x	x	x	x
Moose	x	x	x	x
Caribou	x	x	x	
Bison		x	x	
Mountain goat				x
Dall sheep	x	x	x	

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Dusky shrew	x	x	x	x
Pygmy shrew		x		x
Little brown myotis			x	x
Collared pika		x	x	
Arctic hare	x			
Snowshoe hare		x	x	x
Woodchuck		x		
Hoary marmot	x	x	x	x
Arctic ground squirrel	x	x	x	x
Red squirrel		x	x	x
Northern flying squirrel		x		
Beaver		x	x	x
Greenland collared lemming	x	x		
Northern bog lemming		x	x	x
Brown lemming	x	x	x	x
Red-backed vole	x	x	x	x
Meadow vole		x	x	
Long-tailed vole		x		
Yellow-cheeked vole		x		
Tundra vole	x	x	x	x
Alaska (Singing) vole	x	x	x	x
Muskrat		x	x	x
Porcupine		x	x	x
Coyote	x	x	x	x
Gray wolf	x	x	x	x
Arctic fox	x	x	x	x
Red fox	x	x	x	x
Black bear		x	x	x
Grizzly/Brown bear	x	x	x	x
Polar bear	x			
Marten		x	x	x
Short-tailed weasel	x	x	x	x
Least weasel	x	x		
Mink	x	x	x	x
Wolverine	x	x	x	x
River otter	x	x	x	x
Lynx	x	x	x	x
Moose	x	x	x	x
Caribou	x	x	x	
Bison		x	x	
Mountain goat				x
Dall sheep	x	x	x	

Table 8.2.1-7 Birds that may be encountered within either the right-of-way or the zone of influence of the trans-Alaska pipeline

Presence within the major drainages as either breeding, nonbreeding, summering, wintering or migrating birds is denoted by "X" for common occurrence and an "*" for either rare or accidental occurrence; names of endangered species are underlined.

Sagavanirktok R.	Yukon River	Copper River	Lowe River	Species	Sagavanirktok R.	Yukon River	Copper River	Lowe River	Species	Sagavanirktok R.	Yukon River	Copper River	Lowe River	Species
*	X	X	X	Common Loon	X	X	X	X	Semipalmated Plover		X	X	X	Hairy Woodpecker
X	X		*	Yellow-billed Loon	*	*	*		Killdeer		X	X	X	Downy Woodpecker
X	X	X	X	Arctic Loon	X	X	*	X	Black-bellied Plover		X	X	X	N. Three-t. Woodpecker
X	*	*	X	Red-throated Loon		X	X	X	Surfbird	X	X	X	X	Say's Phoebe
X	X	X	X	Red-necked Grebe	X	*	*		Ruddy Turnstone	*	X	X	X	Traill's Flycatcher
X	X	X	X	Horned Grebe		*	*	X	Black Turnstone	*	X	X		Western Wood Pewee
			X	Fork-tailed Petrel	X	X	X	X	Common Snipe		X	X	X	Olive-sided Flycatcher
			X	Double-crested Cormorant	X	*	*	X	Whimbrel	X	X	X	X	Horned Lark
			X	Pelagic Cormorant	*	*			Eskimo Curlew	*	X	X	X	Violet-green Swallow
			X	Red-faced Cormorant	*	X	X		Upland Ployer	X	X	X	X	Tree Swallow
X	X	X	X	Whistling Swan	X	X	X	X	Spotted Sandpiper	X	X	X	X	Bank Swallow
	X	X	X	Trumpeter Swan	*	X	X	X	Solitary Sandpiper	*	*	*	*	Barn Swallow
X	X	X	X	Canada Goose	X	X	X	X	Wandering Tattler	X	X	X		Cliff Swallow
X	*	*		Black Brant				X	Greater Yellowlegs	*	X	X	X	Gray Jay
X	X	X	X	White-fronted Goose	X	X	X	X	Lesser Yellowlegs				X	Steller's Jay
X	X	X	X	Snow Goose				X	Rock Sandpiper	*	X	X	X	Black-billed Magpie
X	X	X	X	Mallard	X	X	X	X	Pectoral Sandpiper	X	X	X	X	Common Raven
	*	*	X	Gadwall	X	X			Raird's Sandpiper				X	Northwestern Crow
X	X	X	X	Pintail	X	X	X	X	Least Sandpiper	*	X	X	X	Black-capped Chickadee
X	X	X	X	Green-winged Teal	X	*		X	Dunlin		X	X	X	Boreal Chickadee
	X	X	*	Blue-winged Teal			X	X	Short-billed Dowitcher				X	Chestnut-backed Chickadee
X	X	X	X	American Widgeon	X	*		X	Long-billed Dowitcher		*	*	X	Brown Creeper
X	X	X	X	Shoveler	X	X			Semipalmated Sandpiper	*	X	X	X	Dipper
*	X	X		Redhead	*	*		X	Western Sandpiper				X	Winter Wren
	X	X		Ring-necked Duck	*	*			Buff-breasted Sandpiper	X	X	X	X	Robin
	X	X	X	Canvasback	X				Bar-tailed Godwit	*	X	X	X	Varied Thrush
X	X	X	X	Greater Scaup	X	X	X	X	American Golden Plover	*	X	X	X	Hermit Thrush

Table 8.2.1-7 Continued

Sagavanirktok R.	Yukon River	Copper River	Lowe River	Species	Sagavanirktok R.	Yukon River	Copper River	Lowe River	Species	Sagavanirktok R.	Yukon River	Copper River	Lowe River	Species
*	X	X	X	Lesser Scaup	X	*		X	Sanderling		X	X	X	Swainson's Thrush
*	X	X	X	Common Goldeneye	X	*		*	Red Phalarope	X	X	X	*	Gray-checked Thrush
	X	X	X	Barrow's Goldeneye	X	X	X	X	Northern Phalarope	X	X	X	*	Wheatear
	X	X	X	Bufflehead	X			*	Pomarine Jaeger	X				Bluethroat
X	X	X	X	Oldsquaw	X			X	Parasitic Jaeger		X	X		Townsend's Solitaire
X	X	X	X	Harlequin Duck	X	*		*	Long-tailed Jaeger	X	X			Arctic Warbler
X				Steller's Eider	X	*			Glaucous Gull				X	Golden-crowned Kinglet
X			X	Common Eider		*	X	X	Glaucous-winged Gull	*	X	X	X	Ruby-crowned Kinglet
X				King Eider	X	X	X	X	Herring Gull	X				Yellow Wagtail
X				Spectacled Eider	X	X	X	X	Mew Gull	X	X	X	X	Water Pipit
X	X	X	X	White-winged Scoter		X	X	X	Bonaparte's Gull	*	X	X	X	Bohemian Maxwing
X	X	X	X	Surf Scoter	*				Ivory Gull	X	X	X	X	Northern Shrike
X			X	Common Scoter				X	Black-legged Kittiwake	*	X	X	X	Orange-crowned Marbler
	*	*	X	Common Merganser	X				Ross' Gull	*	X	X	X	Yellow Marbler
X	X	X	X	Red-breasted Merganser	X			X	Sabine's Gull	*	X	X	X	Myrtle Marbler
*	X	X	X	Goshawk	X	X	X	X	Arctic Tern		*	*	X	Townsend's Marbler
	X	X	X	Sharp-shinned Hawk				X	Common Murre		X	X	X	Northern Waterthrush
	X	X	X	Red-tailed Hawk				X	Thick-billed Murre	X	X	X	X	Wilson's Marbler
	X	X		Harlan's Hawk					Black Guillemot	X	X	X		Rusty Blackbird
	X	*		Swainson's Hark				X	Pigeon Guillemot	*	X	X	X	Pine Grosbeak
X	X	X	X	Rough-legged Hawk				X	Marbled Murrelet	*	X	X	X	Gray-crowned Rosy Finch
X	X	X		Golden Eagle				X	Kittlitz's Murrelet	X	X	X	X	Hoary Redpoll
*	X	X	X	Bald Eagle				X	Ancient Murrelet	X	X	X	X	Common Redpoll
X	X	X	X	Marsh Hawk				X	Cassin's Auklet		X	X	X	Pine Siskin
*	X	X	X	Osprey				X	Parakeet Auklet	*	X	X	X	White-winged Crossbill
X	X	*	*	Gyrfalcon					Crested Auklet	X	X	X	X	Savannah Sparrow
X	X	X	X	Peregrine Falcon				X	Horned Puffin	X	X	X	X	Slate-colored Junco
X	X	X	X	Pigeon Hawk				X	Tufted Puffin	X	X	X	X	Tree Sparrow
X	X	X	X	Sparrow Hawk	*	X	X	X	Great Horned Owl	X	X	X	X	White-crowned Sparrow
	X	X	X	Spruce Grouse	X	*	*	*	Snowy Owl	*	*	*	X	Golden-crowned Sparrow
	X	X		Ruffed Grouse		X	X	X	Hawk Owl	X	X	X	X	Fox Sparrow
X	X	X	X	Willow Ptarmigan		X	X		Great Gray Owl		X	X	X	Lincoln's Sparrow
X	X	X	X	Rock Ptarmigan	X	X	X	X	Short-eared Owl				X	Song Sparrow
	X	X	X	White-tailed Ptarmigan	*	X			Boreal Owl	X	X	X	X	Lapland Longspur
	X	X		Sharp-tailed Grouse				X	Rufous Hummingbird	X	*			Smith's Longspur
X	X	X	X	Sandhill Crane		X	X	X	Belted Kingfisher	X	X	X	X	Snow Bunting
			X	Black Oystercatcher	X	X	X	X	Yellow-shafted Flicker					

Table 8.2.1-8 Freshwater and anadromous fish associated with the LNG alternative pipeline route

Lampetra japonica	Arctic lamprey
Entosphenus tridentatus	Pacific lamprey
Acipenser medirostris	green strugeon
Stenodus leucichthys neima	Inconnu
Coregonus pidschian	Humpback whitefish
Coregonus nasus	Broad whitefish
Coregonus sardinella	least cisco
Coregonus laurettae	Bering cisco
Coregonus autumnalis	Round whitefish
Coregonus clupeaformis	Lake whitefish
Prosopium cylindraceum	Arctic cisco
Thymallus arcticus	Arctic grayling
Salvelinus namaycush	Lake trout
Salvelinus alpinus	Arctic char
Salvelinus malma	Dolly Varden
Oncorhynchus kisutch	Coho (silver) salmon
Oncorhynchus tshawytscha	Chinook (king) salmon
Oncorhynchus keta	Chum (dog) salmon
Oncorhynchus nerks	sockeye (red) slamon
Oncorhynchus gorbuscha	pink, (humpbacked) salmon
Salmo gairdneri	rainbow trout
Salmo clarki	cutthroat trout
Esox lucius	Northern pike
Couesius plumbeus	Lake chub
Catostomus catostomus	Longnose sucker
Percopsis omiscomaycus	Trout-perch
Lota lota	Burbot
Cottus cognatus	Slimy sculpin
Myotecephalus quadricornis	Fourhorn sculpin
Gasterosteus aculcatus	Three-spined stickleback
Pungitius pungitius	Ninespine stickleback
Liopsetta glacialis	Arctic flounder

Arctic Slope Drainage--

Mammals--This route crosses the Arctic North Slope along and generally close to the Sagavanirktok River. Ungulate species occurring in this area include caribou, moose and mountain sheep. Carnivores include grizzly and polar bears, wolf, coyote, wolverine, red and Arctic foxes, lynx (occasional), marten (occasional), mink, otter and weasel. Rodents and lagomorphs include the porcupine, snowshoe and tundra hares, marmot, ground squirrel, lemmings (both brown and collared) and several species of voles. Three species of shrews occur there. See figures 8.2.1-15a and 15b for sensitive wildlife habitats.

1. Caribou are the most abundant large mammal frequenting the area traversed by the proposed route. They are also in many ways the most sensitive. This pipeline route threads the overlap area between the summer ranges of the Arctic Caribou herd and Porcupine Caribou herd. (See Figures 8.2.1-16a and 16b.) The two herds mingle along the Sagavanirktok River. The ranges of the Fortymile Caribou herd and Delta Caribou herd flank the route along the central portion and are not affected as are the Arctic, Porcupine and Nelchina herds. The range of the Nelchina Caribou herd is bisected by the route.

The Sagavanirktok Drainage is flanked by the ranges of the Porcupine Caribou herd on the east and the Arctic Caribou herd to the west. Both caribou herds traditionally winter in the foothills and southern slopes of the Brooks Range and summer in the northern foothills and on the Arctic Coastal Plain. Normally few caribou winter north of the Brooks Range, although Collins (1937) described a large wintering concentration of several thousand between the Collville and Kuparuk Rivers. The combined number of caribou in these herds is estimated by Alaska Department of Fish and Game biologists to be 383,000 animals (Arctic herd, 243,000 and Porcupine herd, 140,000) (J. Hemming, personal communication). These two herds intermingle in the summer in the vicinity of the proposed pipeline route, but have traditional calving areas which appear to be the focal point of the range of each herd (Lent, 1966; Skoog, 1968). Calving grounds for the Arctic herd are located in the headwaters of the Utukok and Colville Rivers to the west of the corridor. The Porcupine herd calves on the coastal plain and foothills principally in the northern portion of the Arctic National Wildlife Range to the east of the corridor. The north-south passes, including Atigun Pass on the proposed natural gas pipeline route, are among those used by caribou during late winter through early summer in their northward crossing of the Brooks Range. Atigun Pass now contains a recently completed road and the trans-Alaska oil pipeline is being constructed through the pass.

2. Dall sheep in the high mountains of the Brooks Range are the northernmost species of wild sheep in North America, and are most frequently encountered along the large river drainages.

In early winter as the snowline descends and lowlands become snow covered, sheep descend to their wintering ground on windswept ridges and promontories. At times during winter, they climb to higher altitudes to find exposed vegetation. During this season, sheep are quite confined to these restricted ranges.

Dall sheep breed from late November through mid-December. Lambing occurs from mid-May to mid-June, with most lambs being born prior to June 1. The Atigun Canyon contains the most important lambing area along this route.

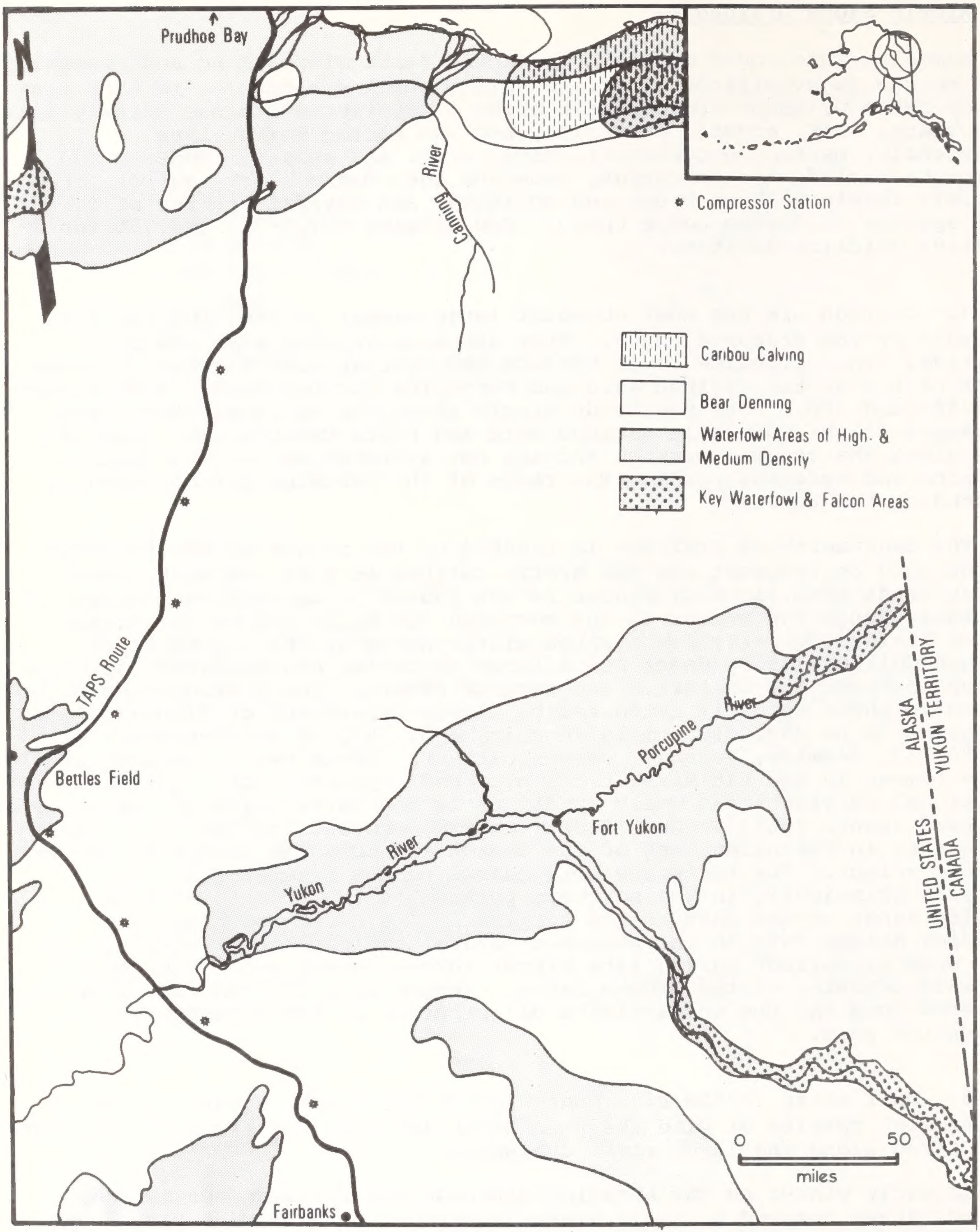


Figure 8.2.1-15a Sensitive wildlife habitat

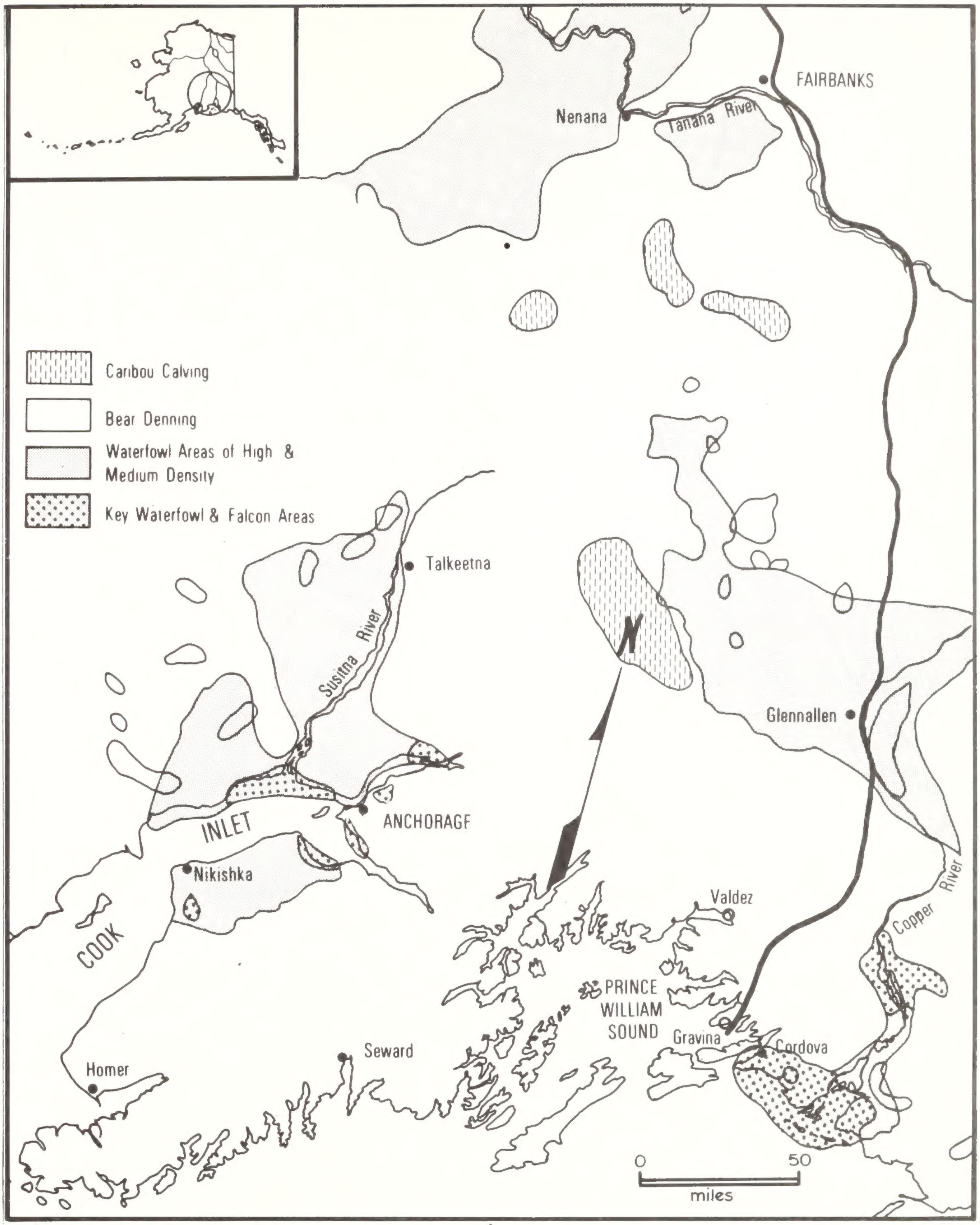


Figure 8.2.1-15b Sensitive wildlife habitat

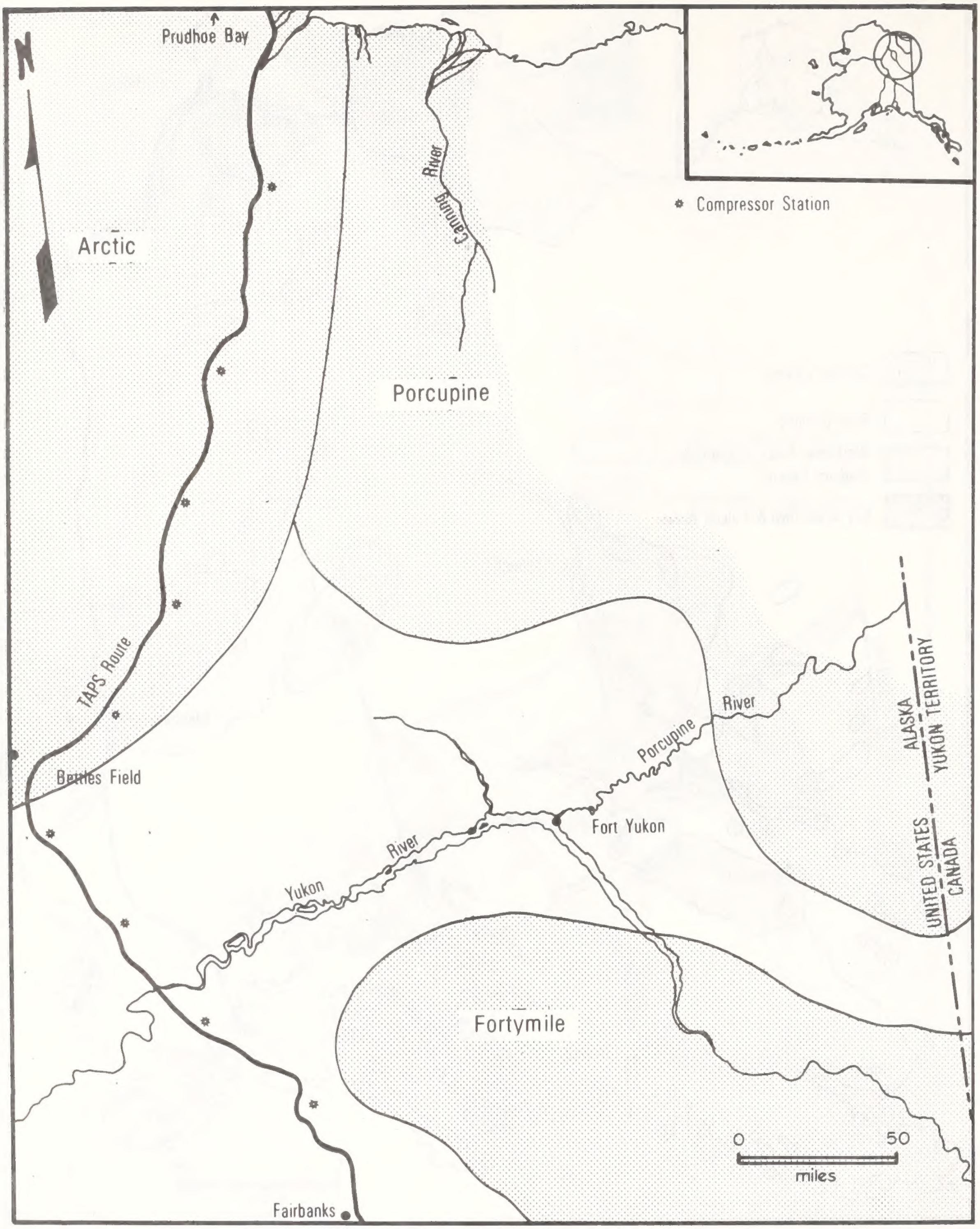


Figure 8.2.1-16a Main Caribou herds of Alaska

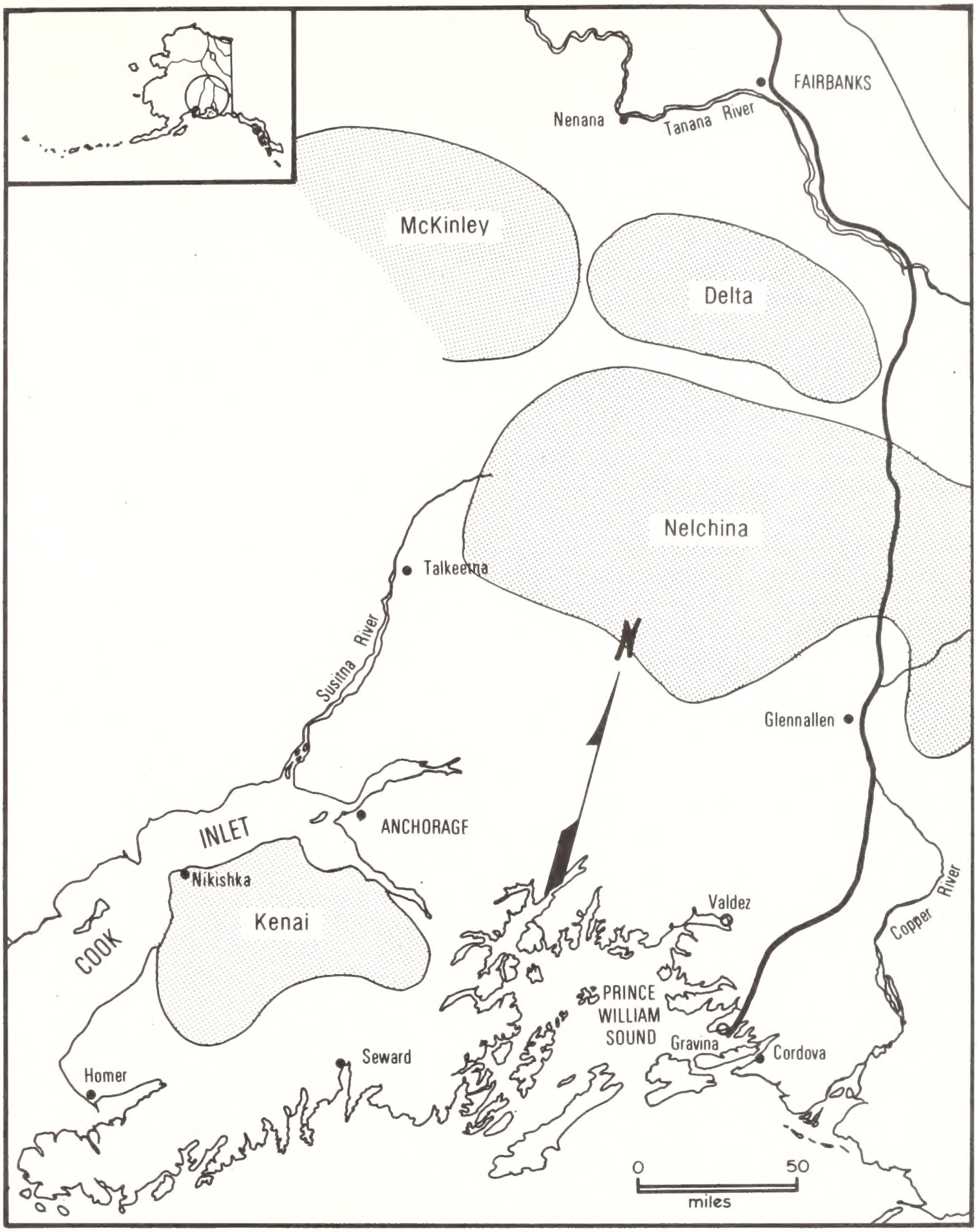


Figure 8.2.1-16b Main Caribou herds of Alaska

With the approach of spring, sheep concentrate on south-facing slopes in valley bottoms where vegetation first becomes green. They may be seen in these valley bottoms at any time of the year, either crossing between mountain ranges or feeding in areas of new plant growth. The animals are seldom far from escape terrain, however.

Dall sheep, particularly the rams, tend to stay in the higher terrain during the hottest part of the summer. During this time they frequent alpine meadows. In the fall as the days cool and the insects disappear, they return to lower elevations. At this time they are found on low mountain slopes, alluvial fans, and valley bottoms, feeding within the shorter and less dense stands of willow. Mineral licks are important to the Dall sheep and several of these occur along the route.

Winter climate is the primary mortality factor, although sheep (principally lambs) are subject to predation by wolves, coyotes, golden eagles, and lynx. Except for man, wolves are the only predators to significantly affect adult sheep.

Dall sheep range on either side of the proposed route in the Alaska range and Chugach Mountains.

3. Moose. On the Arctic Slope, moose are at the northern limit of their range, however their numbers appear to be increasing. Weather, limited winter food supplies, and carnivores are believed the primary limiting factors on the population.

Moose occur in small numbers in most of the major Arctic Slope drainages. The Colville River Drainage supports the largest population; several hundred animals. They occur along the upper Sagavanirktok River wherever sizeable stands of willow grow on the gravel bars. In March-May 1971, there were approximately 45 moose on the Sagavanirktok and Atigun River. Drainages along the pipeline route (E.E. Ludlow, D.R., Klein, personal communication and observations). Some northward movement of moose to the North Slope takes place from the south flowing drainages of the Brooks Range.

Moose range throughout the interior forest portion of this route, concentrate along stream bottoms during the winter months and can be found at most elevations and in most vegetative types during the summer. Moose are scarce in the coastal forests, but again, some can be found along the stream bottoms and open swampy areas.

4. Bears. The grizzly bear is a true indicator species of a wilderness environment. The barren-ground grizzly is probably best regarded as a 'ecotype,' or population adapted to the tundra environment. It is the most northerly and smallest in size of six loosely defined brown-grizzly bear 'ecotypes' and inhabits the northern parts of Alaska and the Yukon in Canada from tree line to the Arctic coast.

This bear is a wanderer, traveling in circuitous routes during the summer and sometimes returning to the same den in the fall. Its reproductive rate is low, and the animal matures more slowly in the arctic than in its range farther south. Longer periods of parental care seem necessary. Females may not breed until they reach 6 years of age.

Grizzly bears utilize the mountain slopes and alpine meadows during the summer and feed primarily on vegetative material. Denning occurs from early November until mid-April for the majority of bears, though variation in timing due to a variety of factors is common. Naturally occuring rock cave or dug dens located on mountain slopes are utilized.

Large numbers of grizzly bears range down the Dietrich River as far as the Middle Fork of the Koyukuk. Southward, smaller numbers can be found all the way to Prince William Sound. In Prince William Sound the grizzly ecotype gives way to brown bear ecotype. Intensive use areas can be found along the Delta and Gulkana River valleys especially during the salmon spawning season. Denning areas flank the Gulkana Valley.

Polar bears can be found in the vicinity of Prudhoe Bay. They forage over the offshore islands when the ice is in and in winter occasionally come into the camps at Prudhoe Bay and Deadhorse.

5. The gray wolf is found throughout the length of the pipeline corridor. Like other predators its distribution reflects the availability of prey species. It occurs wherever caribou herds occur. However, the wolf is capable of utilizing a wide variety of annual life from rodents to dall sheep and moose enabling it to exist throughout Alaska.

Densities, like distribution, are governed by the availability of prey. However, social and biological forces within the wolf population operate also. The limited availability of acceptable den sites is believed to limit wolf numbers in some areas of the North Slope.

6. Furbearers. The most widespread and characteristic furbearers along this route north of the Brooks Range are the Arctic and red fox. The Arctic fox is presently abundant on the Arctic Coastal Plains and is undoubtedly the most important furbearing species in that area. The most important habitat is concentrated along rivers and streams, where predatory furbearing species such as fox and wolves and their prey (Arctic ground squirrels) concentrate their activities during most seasons of the year within the floodplain and cutback communities along major rivers.

Wolverine and short-tailed weasels are also present in this area, although their populations are believed to be low.

Arctic foxes are common on the Arctic Coastal Plain. Their abundance from year to year is directly related to the abundance of their primary prey, the lemming. Although some foxes spend extensive portions of the winter on the sea ice, the species is completely dependent upon denning locations ashore for reproduction. Suitable fox denning sites are scarce as they require deeper thaw and better drainage than is common to the region, and consequently some sites have an extremely long history of use. Elevated ground, such as pingos, sand dunes, river bluffs and benches, which provide the conditions for successful denning are therefore of special ecological importance to the foxes.

Red foxes, although characteristic of the mountains and foothills of the Brooks Range appear to be invading the Arctic Slope and encroaching upon the habitat of the Arctic fox. Denning requirements are similar to those for the Arctic Fox.

7. Small Mammals. Three small insectivores can be found in the Sagavanirktok Drainage; these are the masked, Arctic, and dusky shrews (Bee and Hall, 1956). The masked and Arctic shrews have much the same general distribution and while each species lives in a wide variety of communities they favor slightly different sites. The masked shrew is an inhabitant of

the wetter areas and is most numerous on canyon floors, at the foot of scree slopes, or wherever an increase in soil moisture is favored by local topography. The Arctic shrew is more inclined to seek out plant communities which require a slightly drier site, and have enough local relief to enhance drainage. The dusky shrew seems to require high overhead cover and is a creature of the alder and willow thickets and, therefore, is most common along the banks of major streams. These species of shrews contribute to the biomass and have value because of their place in the food chain (Buckley and Libby, 1957).

Several species of lemmings and voles are present in the area. These are the collared lemming, brown lemming, red-backed vole, tundra vole, and Alaska or singing vole.

The Arctic ground squirrel is distributed throughout the parts of the North Slope that are free of permafrost. They feed rather heavily on the plants of the early successional stages. Sedges and grasses bulk large in their diets because of their concentrations near the shores of Arctic lakes (Bee and Hall, 1956). These animals are an important food item for grizzly bear.

In the Brooks Range the hoary marmot is often found on steep canyon walls which have damp soil and protection from the wind. These sites have a characteristic cover of willows, sedges, lichens and mosses. Bolder fields and talus slopes are important for escape cover and hibernation areas.

The tundra hare and the porcupine are two other species with rather sporadic occurrence within the Sagavanirktok Drainage.

Birds--One hundred and seventy-one species of birds have been reported north of the Brooks Range divide (Bantonek, 1969a), but only about half of those might be commonly encountered in the region of this alternative pipeline route, see Table 8.2.1-7. During May, the first migrants return. The Sagavanirktok River, its delta and tributaries are among the first Arctic waters to open up in the spring and are occupied by many early-arriving ducks, geese and shorebirds until other waters on the coastal plain are ice free. Most nesting of waterbirds, however, takes place on tundra near lakes and ponds that are either adjacent to the rivers or on islands within the delta. Sage (1971) recorded 72 species within the Sagavanirktok and Atigun valleys in summers of 1969 and 1970, and described their distribution within 10 habitat types.

Bird populations in the coastal plain, foothill and mountain regions of the Arctic Slope differ in species composition because of obvious differences in types and numbers of wetlands, types of uplands, and distance from the coast.

Waterfowl are most numerous on the coastal plain. The lakes and potholes provide habitat for breeding waterfowl and shorebirds, especially old squaws, pintails, pectoral sandpipers, dunlins, semipalmated sandpipers, and red phalaropes.

The shorebirds are reported to occur in densities up to 700 birds per square mile of non-water areas in the vicinity of Point Barrow by Pitelka.

Fish and Wildlife Services surveys indicated that populations within the coastal plain averaged at least 16 ducks and 5 geese and brant, per square mile during 1970. The breeding population of ducks during the 1970 survey was comprised of the following: oldsquaws, 37 percent; pintails, 28 percent; eiders, 17 percent; scoters, 9 percent; baldpate, 5 percent; scaup, 3 percent; green-winged teal, trace and mallards, trace. Breeding waterfowl on the Sagavanirktok River delta during 1969 and 1970 (Gavin, 1970) included oldsquaw (28 percent), pintails (22 percent), lesser Canada geese (11 percent), white-fronted geese (10 percent), black brant (6 percent), mallards (1 percent), green-winged teal (less than 1 percent). King (1970) estimated that during the summer of 1967 the populations of the larger species of waterfowl on just the coastal plain included 800 whistling swans, 15,000 Canada geese, 35,000 black brant, 50,000 white-fronted geese, and less than 1,000 snow geese.

For some species of waterfowl on the Arctic Slope there appears to be a disproportionately greater number of nonbreeding birds than breeding birds which suggests that nonbreeders are coming from other areas in the north to summer in this region. Affinities of these nonbreeding waterfowl to their breeding populations elsewhere and of breeding waterfowl to wintering areas in the south have not been determined for most species.

The vast majority of Arctic Slope birds are migratory. Some species such as gyrfalcons, snowy owls, rock and willow ptarmigans and ravens can be found year round, however they too exhibit seasonal movements.

The Arctic peregrine falcon, an endangered bird, nests in the Sagavanirktok Drainage. The Eskimo curlew is also endangered and occurs at times in the area of the proposed route.

Song birds in this area have been grouped by Alaskan Arctic Gas according to their association with various plant communities.

Birds associated with the riparian tall shrub willow vegetation include: willow ptarmigan, rock ptargmigan, semipalmated plover, least sandpiper, yellow wagtail, northern shrike, yellow warbler, common redpoll, and tree sparrow. This association is found most frequently along streams that drain the south face of the Brooks Range.

Tall willow-alder shrub vegetation is found typically along the borders of creeks, rivers, and lakes. Birds likely to be found in this vegetation are: Olive-sided flycatchers, gray jay, American robin, varied thrush, Swainson's thrush, gray-cheeked thrush, ruby-crowned kinglet, Bohemian waxwing, yellow warbler, yellow-rumped warbler, blackpoll warbler, northern waterthrush, Wilson's warbler, rusty blackbird, white-crowned sparrow and fox sparrow. Birds found in willow dwarf birch shrub, which is included with this type, are similar to those found in tall willow-alder shrub, but lean more heavily to the insectivorous perching birds (Schweinsburg, 1974). The dense alder patches often contain fox sparrows and Wilson's warblers.

Birds associated with the heath shrub and lichen vegetation are: water pipit, rock ptarmigan, horned lark, rosy finch, and wheatear. In most situations, American golden plovers, Baird's sandpipers, and Lapland longspurs may occur. The wandering tattler occurs along the rocky streams at high altitudes. Birdlife above 5,500 feet, is sparse, but rosy finches, horned larks, and wheatears sometimes range to the mountain tops. At lower altitudes, where moisture makes it possible for some taller shrubs to grow, birds more typical of the spruce woods and knolls may occur, especially tree sparrows, white-crowned sparrows, redpolls, and American robins.

The spruce-heath-shrub savannah grows in large uninterrupted stands particularly on the southern slope of the Brooks Range. Birds commonly found in this association are: gray jay, American robin, varied thrush, gray-cheeked thrush, Bohemian waxwing, blackpoll warbler, tree sparrow, and white-crowned sparrow. Less common species are: solitary sandpiper, mew gull, common flicker, northern three-toed woodpecker, olive-sided flycatcher, common raven, ruby-crowned kinglet, yellow-rumped warbler, rusty blackbird, pine siskin, and dark-eyed junco.

The birds associated with boreal forest vary depending on the density of the white spruce woods. In the dense areas, birds such as the varied thrush, ruby-crowned kinglet, pine grosbeak, and white-winged crossbill are found.

Wet sedge meadows and tussock-dwarf-heath tundra vegetation types in the Arctic Coastal Plain contained a greater variety of bird species than in the Brooks Range. Wet sedge meadows in the Brooks Range may be the major nesting habitat for the northern phalarope. The common snipe and the savannah sparrow are also found in this habitat in the Brooks Range, usually in the drier portions.

Tussock-dwarf-heath tundra in the lower altitudes of the Brooks Range commonly has nesting least sandpipers, Smith's longspur, and savannah sparrows, and may also include short-eared owls and marsh hawks. Willow ptarmigan are found in the drier, shrubby areas (dwarf shrub-heath) and Lapland longspur is found at elevations of 3,200 to 4,500 feet.

Fish--Table 8.2.1-8 contains a list of freshwater fishes found along this route. Fish that are found in the Arctic Drainage of Alaska are characterized by slow growth (it may take 15 years for a fish to reach 5 pounds), slow development, and long life spans of up to 40 years. These characteristics are primarily the result of low productivity of the waters, a short growing season, and low water temperatures.

Arctic char, Arctic grayling, and round whitefish are the predominant and sometimes only sport fish present. Additional lake trout is an important species with sports and subsistence potential found in lakes of the Brooks Range. Chum and pink salmon have been caught in the Sagavanirktok River, also, but their numbers are few. The Alaska Department of Fish and Game reports catching only three salmon during their studies in this drainage.

Arctic grayling are the most abundant sport fish in the area and occur in all drainages. Grayling prefer clear waters of streams and lakes and commonly school in pools below rapids. Department of Fish and Game data indicates that it may require 8 years for a grayling to reach a length of 14 inches. Slow growth and ease of capture make them susceptible to local extirpation. For these reasons grayling cannot cope with man's encroachment. In fall, grayling leave the small streams and migrate to deep pools in larger rivers for winter.

Both anadromous and resident populations of arctic char are present. Major runs of char are known to occur annually in the larger rivers of the arctic slope. Spawning takes place during the fall in gravel beds within the rivers. The fish overwinter in the deeper holes in rivers or at spring sites before returning to the sea. Growth rates are very slow, and it may take 15 years for a fish to reach 5 pounds.

The round whitefish is one of the most widespread and common species of fish found in northern waters. They occur in all major drainages and in coastal lagoons. Lake and broad whitefish are less common. Whitefish are important in the subsistence diet of the inhabitants of the area.

Cisco are common residents of lakes, rivers, and streams in the region and are important forage for lake trout, pike, and burbot.

Burbot, also known as inland or freshwater cod or ling, is the only member of the cod family found in freshwater. It is widely distributed in deep lakes and larger streams of the region, where it preys on whitefish. The fish frequents the bottom, staying in deep waters but moves into shallow waters to spawn.

Ninespine stickleback are common also. Other non-sport fish which can be found are slimy sculpine, Arctic cisco and least cisco.

Perennial springs which provide the only source of water in the streams during the winter period are critical to the survival of overwintering populations of freshwater fishes in the Beaufort Sea drainages.

Yukon River Drainage--The Yukon River system and associated watershed supports a broad diversity of fish and wildlife habitat. Except for the larger tributary river valleys and the mountainous areas along the Brooks and Alaska Ranges, the terrain is rolling and vegetated primarily by spruce-birch interior forests. Along the river valleys the interior forest becomes more diversified and includes some deciduous species. The mountainous areas of the Alaska Range are similar to those of the Brooks Range.

Mammals--

1. Large Game Animals. Moose, bison, caribou, sheep, wolves, black and grizzly bears are common, at least locally, along the Yukon drainage portion of the proposed pipeline route.

Black bears are common also in the forested interior. Hatler (1967) has estimated black bear densities in the Tanana Hills and Fairbanks area at one per 10 square miles and he reported black bears moving into alpine areas in July and August, a habitat usually dominated by the grizzly bear.

Bison have been introduced at two points along this route. Near Delta Junction the route would traverse an area used as fall and winter range by about 250 animals.

2. Furbearers. Furbearers include wolverine, lynx, red fox, coyote, mink, marten, otter, weasel, beaver, and muskrat. Snowshoe hare, red squirrel, pika and porcupine are other intermediate-sized mammals which occur.

Beaver is present throughout the drainage wherever suitable habitat exists. Their preferred foods are aspen and cottonwood followed by willow, birch and alder. They occur wherever these foods are found in conjunction with standing or slow-moving water which does not freeze to the bottom (Buckley and Libby, 1957).

The small game and furbearers in the proposed Rampart Dam impoundment area were studied by Koontz (1968). He found that the mean number of beaver lodges for the 10,500 square mile area was 1,995. He estimated the population at 31,500. The average harvest for the years 1958-1962 was 890 animals per year having a total value of $20,025. He estimated the average population density to be 3 animals per square mile.

Habitat requirements for muskrats is similar to that for beaver. They are found from the Brooks Range south wherever suitable habitat exists. They feed on all parts of herbaceous aquatic vegetation including the roots and tubers. The average annual harvest of muskrat in the Rampart Dam impoundment area from 1925-1962 was 41,040 animals with a value of $50,479 and for the period from 1958-1962 the average annual harvest was 15,169 with an average annual value (in Seattle) of $11,984.

Porcupine feed on the bark and twigs of aspen, white birch, and other trees. They occur almost everywhere they can obtain food. Buckley and Libby (1957) indicate that porcupines might be absent from areas frequented by wolverine since they are easy prey for this animal.

The snowshoe hare, a species subject to violent population fluctuations, is found all along this section of the proposed route wherever food and cover are adequate. During the last few years, population numbers have been almost continually high along some segments of the route. The lynx is the prime predator on these hares and its population is quite closely tied to the cyclic fluctuations of the hares.

The hoary marmot inhabits all mountain ranges crossed. It is usually found on stable slopes where large boulders and a variety of foods occur. The Alaska ground squirrel is often found in the same areas but can usually be found also in any well drained, permafrost free soil.

Another common rodent in the higher passes is the pika. It inhabits talus slopes and rubble areas in the Alaska Range and Chugach Mountains. Being active year around, they collect and dry grass and forbs for use as winter food.

The range of the red squirrel within this area is the same as that of the white spruce, the seeds of which are its principal food. The northern flying squirrel can occur anywhere in the area where there are tall spruce or spruce mixed with other tall trees. Their main food is probably spruce seeds.

Koontz (1968) reported population densities for a number of animals in the Rampart Dam impoundment area:

Species	Estimated Density	Estimated Population
Beaver	3/1 sq. mi.	31,500
Mink	2.2/1 sq. mi.	23,100
Marten	1/5 sq. mi.	2,100
Otter	1/150 sq. mi.	3,360,000
Short-tailed weasel	1/1 sq. mi.	10,500
Lynx	1/5 sq. mi.	2,100
Red fox	1/2 sq. mi.	5,250
Wolf	1/50 sq. mi.	210
Wolverine	1/80 sq. mi.	131
Snowshoe hare	140/1 sq. mi.	1,470,000
Red squirrel	12/1 aq. mi.	126,000

3. Small Mammals. The dusky, masked, Arctic, and pygmy shrews are all found in some locality in this area. The pygmy shrew is by weight probably the smallest mammal in the world. Its habitat preferences are similar to those described for the North Slope.

Several species of small rodents are known to occur also. These include the: northern bog lemming, brown lemming, collared lemming, northern red-back vole, meadow vole, long-tailed vole, yellow-cheeked vole, tundra vole, Alaska vole, and the meadow jumping mouse. The bog lemming prefers low swampy areas where grasses, sedges, and mosses are major components of the vegetation. The meadow vole prefers meadows with dense grass. The long-tailed vole occurs from the Salacha River the the Alaska Range and it apparently prefers meadows of a somewhat drier type than those of the meadow vole. The yellow-cheeked vole has been collected most often in areas of wet black spruce muskeg with a ground cover predominantly of moss and a shrub layer of alder (Buckly and Libby, 1957). The meadow jumping mouse ranges from the Yukon River south preferring grassy meadows and open woodland. The other small rodents show preference for habitat types similar to those that occur north of the Brooks Range.

Refer to Table 8.2.1.-6 for a list of mammal species present in this drainage.

Birds--At least 161 species of birds have been reported from interior Alaska, and perhaps three-fourths of these might be regularly encountered along this alternative pipeline route within this particular region (Tables 8.2.1-7). Some of the more common birds of the interior have been listed by major types by Kessel, et. al. (1957) and Buckley and Libby (1957). Population estimates for most nongame species within this region are almost nonexistent.

Weeden and Ellison (1968) described the valuable game birds of Alaska and noted that periodically good numbers of willow ptarmigan, rock ptarmigan, spruce grouse, ruffed grouse and lesser numbers of sharp-tailed grouse can be encountered in parts of the interior. With the advent of fire protection, habitat is tending to be maintained in late successional stages to the benefit of spruce grouse but to the detriment of sharp-tailed grouse which favors an early successional stage that is often maintained by fire.

The fall numbers of ducks migrating from principal waterfowl habitat within the Koyukuk River drainage, Yukon Flats and in the Tanana-Kuskokwim lowlands, portions of which are either adjacent to or downstream from the route, are given in Table 8.2.1-9. Other species of ducks are found in smaller numbers. No reliable estimates are available for white-fronted geese and lesser Canada geese, both of which nest in most large tracts of waterfowl habitat in the northern half of the interior lowlands and probably number in the tens of thousands.

The route would cross good waterfowl habitat in the Kanuti Flats, the Ray River, the flood plains of the Tolovana and Chatanika Rivers, the oxbows and ponds along the Chena and Slacha Rivers and morainal ponds near Donnelly Dome and several other areas of lesser importance (Bartonek, 1969b). It would also traverse several drainages entering Minto Flats which is important both as a waterfowl hunting area for sportsmen from the Fairbanks area and as a waterfowl production area (Hooper, 1952).

King (1968b) estimates from extrapolation of 13 years of waterfowl inventory data that somewhat fewer than 315 trumpeter swans, a formerly endangered and still rare species, were present in the lower Koyukuk Valley during the spring. He also reported 340 adult and immature plus 138 young trumpeter swans during a late-summer survey count during 1968 in the Fairbanks area which included Minto Flats and portions of the Tanana Valley, Wood River and Kantishna River. Drainages of some of these aforementioned areas would be traversed by the route.

Recoveries of waterfowl banded on the Yukon Flats demonstrate the continental value of this resource.

Sandhill cranes are common migrants through the State and some nest in the interior. Cranes sometimes cause depredation problems on the limited

Table 8.2.1-9 Estimates of migrating duck populations from habitat in the Yukon River drainage adjacent to or downstream from the proposed pipeline route

	Koyukuk Drainage	Yukon Flats	Tanana-Kuskokwim
Mallard	92,000	130,000	80,000
Pintail	181,000	256,000	158,000
G-w teal	124,000	176,000	109,000
Am. widgeon	136,000	192,000	119,000
Shoveler	46,000	65,000	40,000
Canvasback	11,000	16,000	10,000
Scaups	159,000	225,000	139,000
Goldeneyes	40,000	57,000	35,000
Bufflehead	19,000	27,000	16,000
Scoters	41,000	58,000	36,000
Oldsquaw	11,000	2,000	1,000
Total	850,000	1,161,000	743,000

Source: King, 1968a

farmlands in this area, but they also provide hunting and aesthetic values both here and along their migration route.

A number of raptors can be found in the variety of habitats that may be crossed by this alternative. Gyrfalcons, golden eagles, and rough-legged hawks are common in the higher elevations such as the Alaska Range. Peregrine falcons are found in the foothills of the Brooks Range. Along the Yukon, Tanana, Delta and Salacha Rivers a number of active or formerly active eyries are located close to the route.

Goshawks are the most common raptor of the interior forest. Redtailed hawks and Swainson's hawks are also fairly common.

Great horned owls are common year around in the interior. The great grey owl is present and probably much more common than generally realized. Hawk-owls and boreal owls are also relatively common. The short-eared owl is a common open country hunter during the summer.

The small birds present typify those found in the boreal forest. A comprehensive list covering most of these birds can be found in Table 8.2.1-7.

Fish--Typical subarctic area fish species are found in the Koyukuk River system which drains the south slopes of the Brooks Range. It is part of the Yukon Drainage. Grayling are the most important fish.

Salmon have long been thought absent from upper reaches of this drainage. In recent years they appear to be reentering the upper reaches of the Middle Fork of the Koyukuk River. Chum and chinook salmon have been found there in small numbers. Spring areas in the larger streams are focal points for spawning.

Burbot, northern pike, and several whitefish also occur in these stream systems. Closer to the Yukon River the more diverse fish populations of the area are encountered.

The Yukon River dwarfs all others in Alaska with a drainage area of 330,000 square miles, one third of which is in Canada. The streams along and near this alternative route in this river system are as variable as the terrain within the drainage basin. The species of fish that inhabit these waters are equally variable.

The Yukon has long been noted for producing catches of salmon which migrate as far as 2,000 miles upriver to headwater areas to spawn. These salmon, with their capacity for extremely long migrations, represent unique and irreplaceable races of their species and are much esteemed for their exceptional quality. While the main economic value of these salmon is commercial and subsistence fishing, they also provide considerable sport fishing.

The tributaries to the Yukon River that flow directly out of the Brooks Range are the Dietrich, South and Middle Forks of the Koyukuk, and the Jim Rivers. All are relatively clear streams with gravel to cobble size beds. The most common fish species found in the drainage are grayling, sculpins, suckers, and whitefish. Chum salmon and a few chinook salmon migrate up the Koyukok at least as far as Cold Foot.

Lake trout are found in the deeper lakes. Dolly Varden trout have been found in some of the mountain streams and northern pike are found in many lakes from the Brooks Range south.

Most of the streams that enter the Yukon in the general area of the route contain grayling and whitefish, but many also contain northern pike, burbot, inconnu, and suckers. Further to the south, the Tanana River and many of its tributaries contain grayling, whitefish, burbot, inconnu, northern pike, and suckers; some of the streams support runs of chinook, chum and coho salmon also.

Many excellent streams in the Fairbanks area are readily accessible to sport fishermen. The Chena River alone supports about 25,000 fisherman hours of angling annually. The Delta River, although turbid and highly braided, contains grayling, burbot and whitefish. Headwaters of the Delta River however, are clear and produce excellent grayling fishing. Many tributaries that would be crossed by the proposed pipeline further downstream are fed directly by glaciers, have a steep gradient and contain few fish.

Copper River Drainage--

Mammals--This section of the route which extends from Isabel Pass in the Alaskan Range to Thompson Pass in the Chugach Mountains is like the Yukon River Drainage in the interior forest region. The mammals are similar and most of them have already been discussed. Refer to Table 8.2.1-6 for a complete list.

This alternative route passes through major winter-use areas of the Nelchina caribou herd and either of these areas may contain 10,000 to 20,000 or more caribou during the winter months (December through March). The relative numbers in each area and their boundaries are highly variable, however. This herd usually spends the summers to the west of this corridor and during migration part or all of the herd would be required to cross any pipeline construction here.

Moderately high moose populations are found throughout most of this section. The Gakona and Gulkana drainages support densities of moose that are among the highest in the entire area. Bishop (1969) reports average densities of 0.50 to 0.87 moose per square mile in these areas.

Black and grizzly bears and wolverines are common throughout the area. Grizzlies are estimated to number 1,000 and black bears 3,500 in the Copper River drainage. Grizzly bears are most concentrated along the Delta and Gulkana Rivers. Their denning areas flack the Gulkana Valley.

Wolves are numerous throughout the Nelchina caribou range. Estimates by the Alaska Department of Fish and Game for 1968 listed 300 wolves in the area. In the proposed Rampart Dam impoundment area their diversity was estimated at one wolf per 50 sq. mi.

Dall sheep are abundant in the adjacent Wrangell and Chugach Mountains, and mountain goats are found in the mountains from Tonsina southward. An introduced herd of about 120 bison normally winters near this corridor between Gulkana and the Tonsina River.

Birds--The birds in this route segment are boreal forest species similar to those in the Yukon River Drainage. Refer to Table 8.2.1-7 for a list of species.

The fall numbers of ducks migrating from principal waterfowl habitat within the Copper River-Nelchina River Basin, portions of which are either adjacent to or downstream from the pipeline corridor, are given in Table 8.2.1-10. Other species of ducks are represented in smaller numbers.

Local areas of good duck habitat are found along the Gulkana River between and including Summit and Paxson Lakes, in thaw lakes between Hogan Hill and Glennallen, Willow and Pippin Lakes, and ponds adjacent to the Tonsina and little Tonsina Rivers. The Copper River Delta is an outstanding goose, duck, and swan production area and is frequented during hunting season by hunters from Cordova.

Geese are uncommon breeders in the interior Copper River Basin. The dusky Canada goose, however, which numbers about 25,000 birds (Chapman, et. al., 1969), breeds only along the Gulf of Alaska coast from the Bering Glacier to Cook Inlet but mainly on the Copper River Delta and winters in western Oregon (Hanson, 1962).

King (1968b) reported 400 adult and immature plus 190 young trumpeter swans counted during late-summer surveys conducted during 1968 in the Copper River-Nelchina River Basin and 114 adult and immature plus 44 young trumpeter swans in the Copper River Canyon. Between 500 and 700 trumpeter swans were found on the Copper River Delta (State of Alaska, 1971); and 1,022 trumpeter swans were counted on the Gulf of Alaska coast, including the delta, in 1968 (King, 1968b).

Fish--This system includes some of the most valuable fish producing waters on any segment southward from Prudhoe Bay. As with the Yukon system, there is considerable variation in the characteristics of streams that would be crossed by this alternative pipeline within the Copper River system.

The Gulkana River is accessible by road throughout most of its length, and contains the most important sport fishery of the Copper River system. Some 100,000 sockeye and 20,000 chinook salmon plus an unknown number of steelhead trout migrate up this stream annually to traditional spawning areas (Ken Roberson, personal communication). These fish plus abundant populations of rainbow trout and grayling, provide a large amount of sport fishing annually. Fish Creek alone supports an annual spawning run of sockeye salmon to upstream Fish Lakes estimated in 1969 to be some 20,000 fish (Ken Roberson, personal communication).

Paxson and Summit Lakes are located in the alpine country in the Alaska Range and are large, clear and deep. Both support a considerable sport fishery and are important rearing areas for sockeye salmon hatched in the upper Gulkana and Fish Lakes area (Fred Williams, personal communication).

Other major tributaries of the Copper River include the Tazlina, Klutina, and Tonsina Rivers. These sizeable streams are characteristically "milky" in color due to glacial runoff, yet they support sizeable runs of sockeye, chinook, and coho salmon and some steelhead trout (Myren, 1971). Resident fishes include Dolly Varden, burbot, and lake trout. The Tieckel River contains a resident population of Dolly Varden trout and supports some sockeye and coho salmon below the route crossing. The Little Tonsina River, an exceptionally high-quality, clear stream, supports a resident population of Dolly Varden trout and grayling plus spawning runs of chinook and coho salmon (Van Wyhe, 1969).

Table 8.2.1-10 Estimates of duck populations migrating from habitat in the Copper River drainage adjacent to or downstream from the proposed pipeline route

Mallard	38,000
Pintail	75,000
G-w teal	52,000
Am. widgeon	57,000
Shoveler	19,000
Canvasback	5,000
Scaups	66,000
Goldeneyes	17,000
Bufflehead	8,000
Scoters	17,000
Oldsquaw	1,000
TOTAL	355,000

Source: King, 1968a

Lowe River Drainage--

Mammals--From Thompson Pass to Gravina Point the most important wildlife habitats that might be traversed by this alternative route are those of brown and black bears.

Mountain goats also occur in this region in moderate densities. They summer high in the alpine meadows and precipitous mountain slopes but move down to lower slopes as snows cover the alpine vegetation. Wintering areas are often among cliffs and rocky outcrops on steep forested slopes close to the bottom of the valleys.

Sitka black-tailed deer occur in the Prince William Sound area. Their numbers are limited by the availability of winter forage. The proposed Gravina terminal eliminates one of these wintering areas.

The small mammals that occur within this drainage are similar to those of the preceding drainage. They are listed in Table 8.2.1-6.

A number of marine mammals can be found near the Gravina Point terminal. These include sea otters, harbor seals, sea lions; minke, sei, bowhead and killer whales; and Dall and harbor porpoises. These species and several others also frequent the planned shipping channels and the vicinity of the receiving ports on the California Coast. In deference to conciseness, all of these species are discussed later in this volume under the major heading LNG Transport (Marine Route).

Birds--Nearly 150 species of birds can be found with some degree of certainty within the Lowe River and associated drainages entering Port Valdez. Grinnell, an early ornithologist, conducted an ornithological investigation in the Prince William Sound area, and Kessel et al., (1967) described the typical avifauna of the area.

Waterfowl numbers are small within the Lowe River Canyon when compared to interior lowland habitat, but significant numbers can be found along the parallel tributaries near its mouth. Although perhaps of little continental importance, the Lowe River and drainages are important to local waterbirds.

Bald eagles congregate along the streams in large numbers during the spawning migration of salmon. The greatest concentrations of nesting bald eagles in Prince William Sound are located in the Port Fidalgo and Gravina Point areas.

Some passerines, such as the chestnut-backed chickadee, reach the northern limits of their range in this area. Rufous hummingbirds, Steeler's jays, winter wrens, and song sparrows are coastal species that can be found in the Port Valdez area. The white-tailed ptarmigan can be found in the alpine habitat near Thompson Pass. Refer to table 8.2.1-7.

The marine influence is evident; gulls, terns, kittiwakes, jaegers, alcids, shorebirds and cormorants can be found along the shore and within Port Valdez. This area is used by waterbirds during all seasons of the year. Bird populations in Port Gravina are similar to those in Port Valdez shore and within Port Valdez. This area is used by waterbirds during all seasons of the year. Bird populations are similar in Port Gravina as in Port Valdez.

Areas such as the Yukon Delta, Chagvan Bay, Izembek Lagoon, the Susitna Flats, the Chicakloon Flats, Unimak Pass, Orca Inlet, the Copper River Flats and Stikine Flats are key points in the annual migrations of many species of birds entering and leaving the Arctic. Several of these areas serve as migration funnels and serious environmental degradation or catastrophic occurrences at critical times would have serious implications for many of the zoo species living on or migrating along the Pacific coast.

The north central and northeastern coast of Prince William Sound has the highest nesting density of bald eagles in south central Alaska. In the vicinity of the Point Gravina site, 16 active nests were found between Gravina Head and Sheep Point during surveys in 1973 (USFWS, unpublished data). None of these nests is further than 5 miles from the potential site and all face directly toward the area of greatest concentration of vessel traffic associated with the site.

Fish, Shellfish, etc.--The Lowe River is typically turbid in the summer because of silt derived from melting glaciers; in the fall and winter it is typically clear. Resident populations of Dolly Varden trout occur in this system which also is an important production area for sockeye, pink, and chum salmon (Van Wyhe, 1969). Much of the salmon spawning occurs in the small tributaries of the river (N. F. Netsch, personal observations).

Streams from Lowe River to Gravina Point flowing directly into Prince William Sound are typically smaller. The lower reaches, which are frequently in the intertidal zone, are spawning areas for pink and chum salmon. A short distance inland, many of these streams are precipitous and upstream movements of fish from the Sound are limited. Several of the streams that do not have such barriers support runs of coho salmon.

Unless otherwise indicated, material in this subsection is taken from Prince William Sound Briefing Material, ACFEC 1973. Fishery resource information presented here was taken from commercial fishery records. Where resource data is not available it is necessary to rely on catch records by species, gear type and area to abstract necessary biological parameters.

The commercial salmon fishery is the single most important commercial fishery of the region. The fishery is distributed along the migration routes of salmon to the spawning grounds, throughout the Prince William Sound region, and around the mouths of the Copper and Bering Rivers. Pink and chum salmon in the Copper and Bering Rivers are the most important species numerically and by value of product.

Fishery resources of the Copper and Bering River areas also include substantial runs of sockeye, coho, and chinook salmon and marine shellfish. These aquatic organisms depend on the fresh and salt water of the river and estuarine system and the near-shore marine environment (Myren, 1971).

The time of appearance of adult spawning populations in Prince William Sound may be as early as May for unusual chum salmon runs and as late as October for some coho salmon runs. Sockeye salmon runs appear in June and again in August; early pink salmon runs appear in late June. Certain populations of pink salmon have been classified as early, middle, and late runs. During most years the middle to late runs compose most of the catch, but some exceptions occur. Spawning is virtually completed by September 20, with the exception being the spawning of some chum salmon in early October. Chum salmon spawning in Galena Bay begins in late June and pink salmon spawning begins about July 1 (Myren, 1971).

Shellfish represent an expanding fishery of increasing commercial importance in Prince William Sound region and the waters adjacent to the Copper and Bering Rivers.

The king crab fishery is comparatively small in catch size and value compared to dungeness and tanner crab fisheries. King crab fishing in

Prince William Sound is done mostly in the more distant southern waters of the Sound. King crab and tanner crab are primarily caught during the latter part of the calendar year.

The tanner crab fishery began in 1968. With exception of 1971, when catches dropped to half that of the previous year, it has been a fast-growing fishery. Catches reached an all-time high in 1972 of 8.5 million tons.

In the early 1960's the dungeness crab fishery predominated shellfish catches, ranging between 2.2 and 3.4 million pounds annually. Catches began to decline in 1966, and have since fluctuated considerably.

Spot shrimp is the major species of shrimp caught in Prince William Sound. Because spot shrimp inhabit rough, rocky areas, this is exclusively a pot fishery. Stocks of pink shrimp may be present in the southern part of the sound, but little information seems to be available concerning this specific resource.

Production and estimated value of razor clams from the Copper River District for the period 1948-1959 follows:

	Production (pounds)	Value to Fishermen
Average	1,196,880	$299,200
Maximum	1,535,119	$383,700

This fishery, although inoperative in recent years, is expected to resume operations in the future (Myren, 1971).

The commercial reduction herring fisheries have in the past been a valuable resource of the region. Within the past 2-3 years, purse seine catches of herring in Prince Wlliam Sound have shown significant increases as a result of market availability and high market prices. Presently the total herring production is exported to Japan as sac roe and whole frozen herring products.

Halibut fisheries occur within Prince William Sound and in the waters adjacent to the Sound and the Copper and Bering River system. These fisheries are the second most valuable fishery resource. An estimated 75 percent of the catch is taken outside of the 12-mile limit. The resource is caught primarily by large vessels from the lower United States and Canadian fishing ports. (Myren, MRF #86, 1971).

Additional fisheries material can be found in the section on the marine environment.

Other Wildlife Forms in Alaska--

Amphibians--The wood frog occurs in all the forested regions of interior Alaska. The boreal toad may come in contact with this alternative route in the Point Gravina area. It is known to occur just to the east in the Copper River Delta. No other amphibians or reptiles are known to occur in the area.

Invertebrates--The insects of Alaska are not scientifically well known since systematic study of the area has only recently started.

The Alaskan insect fauna differs from that elsewhere in that it is dominated by the Diptera (mosquitoes, houseflies, etc.) both in number of species and number of individuals. It has been said that the total combined weight of the mosquitoes is greater than that of the caribou (Washburn, personal communication).

The principal groups of Diptera, as measured by their impact on man, are the Culicidae (mosquitoes), Tabanidae (horseflies and deerflies), Rhagionidae, Simuliidae (blackflies, etc.) and Ceratopogonidae.

Certain Diptera replace the Hymenoptera (bees, wasps, etc.) as pollinators in many sub-Arctic and Arctic areas and are important for this reason.

The lepidopteran fauna (butterflies and moths) of Alaska is also little known but seems to be poorly represented both in species and total numbers.

Endangered and Threatened Species--Two birds which breed along this alternative route are officially listed as endangered species. Both are races of the peregrine falcon. The tundra peregrine falcon nests in the Sagavanirktok River Drainage. Its range is limited to Arctic Alaska and Canada. Its numbers were probably never large. The peregrine south of the crest of the Brooks Range are probably all American peregrine falcons. In Prince William Sound the peregrines encountered outside of the migrating seasons are probably all residents of the Peale's race which are not threatened.

A number of whales which do or could occur near the terminals are threatened species. These are discussed in the section on the marine environment.

Ecological Considerations

The primary ecological concerns in the Arctic are the transfer of energy and the sensitive heat budget in which insolation, soil thermal regimes, vegetation and animal life all interact.

There is potential for upset in any system which has a low species diversity or which funnels energy transfers through a single node. The tundra fits both cases. The species diversity is low and there are several cases where energy transfer passes through a trophic level occupied by only a few or even one species.

The tundra has a reputation for being fragile and with respect to the change that can occur through upset of the thermal regime this is probably true. It is also true that the tundra sustains overgrazing lemmings, the passage of large caribou herds and even the dramatic seasonal changes associated with the climate. The system must have a degree of resilience to survive these natural occurrences.

In the interior forest region early seral stages are often the most productive. This can easily be seen along many Arctic stream systems where one of the most obvious and dramatic cyclic changes occurs. The water eating away at the bank on the outside of a curve degrades the permafrost in ice rich soil causing rapid erosion of the stable black spruce forest. There is a corresponding buildup of material on the inside bank because the current is slack there. As a consequence a sequence of successional stages is usually apparent on the inside curves of Arctic streams. Willow and alder on the recent bars are followed by balsam poplar. Aspen and birch are mixed with white spruce farther back. As the insulative mat of mosses and lichens builds up the active layer decreases and black spruce again begins to assume a dominate place in the stands.

These early stages are more productive as demonstrated by increased presence of game like moose and black bear and the greater diversity of small mammal and bird communities in these areas.

The following discussion derived from the El Paso application addresses these aspects more specifically.

Van Cleve, *et al*., (1971) have shown that annual production in alder-dominated shrub thickets near Fairbanks ranges from 407 g/m /yr for both above- and below ground components, depending on the age of the system. With respect to the aboveground component only, annual production ranges from 289 to 425 g/m/yr. From the energetic point of view, these systems are highly productive (Van Cleve, 1973). Data of Johnson and Vogl (1966) imply similar rates of production in the Yukon flats area.

Balsam poplar communities that follow shrub types in succession along rivers in interior Alaska (Viereck, 1970a) are also highly productive. Thus, the early portion of the rejuvenation phase is much more productive than tundra systems and, as will be shown below, more productive than subsequent phases.

Aspen and birch types, while having higher standing crops than shrub types, have lower rates of annual production than shrub thickets. They also have a lower annual production than balsam poplar types, as well as lower standing crops. Data of Johnson and Vogl (1966) indicate annual production on the order of 120 g/m /yr, but because of the nature of the data, these figures should probably be increased slightly (Van Cleve, personal communication).

Annual production of white spruce forests is less than that of the above types, and represents the transition between the rejuvenation phase and the senescent phase, which is characterized by open, low growing spruce forests and muskegs. The senescent phase has a low rate of production with respect to the rejuvenation phase and also with respect to the white spruce type This final phase may be similar in productivity to tundra types (Van Cleve, personal communication).

The mechanism responsible for the type of production wave postulated by Louchs (1970) is related to the nutrient cycling dynamics, particularly nitrogen cycling in forest systems (Van Cleve, personal communication). It is known that early stages of succession characterized by alder ecosystems are periods of rapid nitrogen buildup in the soil, which is due to the nitrogen-fixing capabilities of the alder (Van Cleve, *et al*., 1971). This rapid accumulation of nitrogen decreases as succession proceeds, and probably reaches a maximum during the late rejuvenation phase, followed by a net loss from the soil during the senescent phase. The nitrogen lost from the soil is probably tied up in the standing crop, and is thus unavailable to support further rapid production--hence, the low rates of production found in the senescent phase.

In addition, the buildup of feather moss during succession lowers growing season soil temperature and decreases the active layer (Viereck, 1970b). This lowering of soil temperature is probably also associated with decreasing productivity.

The effect of disturbance to such systems is two-fold: (a) nutrients are released, and (b) soil temperature is raised. Thus, the mechanism generating the production wave is probably a gradual tying-up of nutrients and lowering of soil temperature, coupled with random disturbance effects.

Because of more favorable climate, greater structural diversity in the environment, and greater input by primary production, more species of consumers occur in the taiga than in the tundra. The herbivore-based food chains are substantially better developed in this region than on the Arctic Slope, although as yet little is known about invertebrate herbivores in general. Saprovore-based food chains are not as conspicuous as in the tundra but doubtless are of more importance.

Some destructive phytophagous (plant-eating) insects are well known because of their actual or potential economic threat to timber resources. Chief among these are approximately 17 species of Scolytidae (spruce bark beetles) that can erupt from their normal resource base of fallen timber to attack and kill living trees, under certain circumstances (Hand, 1967; Berkwith, 1972a and 1972b). Destructive eruptions of these beetles commonly occur after a substantial source of fallen timber has been provided, allowing the beetle population to grow rapidly. Such fallen timber may result from strong wind, spring breakup, or floods. Once this slash resource is exhausted, mature or over-aged nearby spruce are vulnerable to attack, particularly if many of the living trees are senescent or under some other stress, such as drought.

The abundance of vertebrate consumers in these subarctic latitudes may fluctuate widely. A classic example is the herbivorous snowshoe hare and its obligate predator, the lynx. The periodic peaks in hare abundance have a profound effect on browsable plants. Girdling of small willows and birches in particular results in dieback af all above-ground portions of these species. When preferred species are no longer available, hares frequently begin to consume small white spruce, during the latter stages of a period of abundance. Although the effects of hare outbreaks on plant communities have not been rigorously measured, it is logical to assert that plant species assemblages are significantly influenced by past history of hare browsing. Among the species least subject to browse are several alders (_Alnus_, spp) that are important in building up nitrogen in the soil during early successional stages (Van Cleve, _et al_., 1971).

The mammal and bird consumers in the taiga ecosystem are discussed under the sections on vegetation and wildlife.

Decomposers in interior Alaska are limited in diversity and effectiveness by the same factors as pertain to the Arctic Drainage Division. The limitation upon decomposition rates in the Interior results in a significant net accumulation of both below ground and above ground dead organic matter through primary production.

Soils of interior Alaska tend to be dominated by microfungi and yeasts. Scarborough and Flanagan (1973) recorded 150 species of microfungi in undisturbed forest soils at College, Alaska. These organisms are credited with contributing to the widely observed acidity of taiga soils, as their metabolic products include secretions of organic acids. This acid environment is inimical to bacterial decomposers, which are correspondingly scarce in typical taiga soils (Lindholm & Norrel, 1973).

A complex interrelationship between the organic mat thickness, insulation, temperature and moisture, and nutrient release by microflora characterizes the major lowland communities. These factors distinguish various successional community types, and influence the balance of micrometeorological processes affecting buildup or degradation of permafrost under the plant cover (Viereck, 1970a) in this region of discontinuous permafrost.... A turning point in these relationships seems to be commonly achieved when a moss (Hylocomium spp. Rhytidiadelphus spp. and Sphagnum spp.) layer develops. This surface mat retains moisture effectively, and acts as a wick that remains cold as a result of evaporation, and blocks incoming radiation from warming the soils underneath it.

In general, the amount of biomass produced in the coastal forests at any given state of succession is greater than under similar conditions in the tiaga forests. Due to the lack of fires, successional vegetation is not widespread. Coastal uplift, active flood plains, and retreating glaciers are the primary sources of land on which successional vegetation is established.

High rainfall, cool summers, and moderately low soil temperatures all contribute to slow decomposition rates and the accumulation of organic material on the surface and in the soils. Soils which have developed are high in both organic carbon and iron and relatively low in clay content.

Primary production follows the same successional pattern characteristic of interior basin forests. The gradual increase in standing crop following disturbance reaches a maximum at approximately 100 years, and is followed by a senescent phase leading to low rates of production (Reiners, et al., 1971).

The major difference between the interior basin forests and coastal forests with respect to the primary production is one of degree rather than kind. In general, the amount of dry phytomass produed in coastal forests at any stage in the succession is greater than that found under similar conditions in the interior forests.

Limitation of production is again related to nutrient supply, particularly nitrogen. This element is available in larger quantities in the coastal forest, and accounts, to a large degree, for the increased primary productivity (Van Cleve, et al., 1971).

Economic Factors

History--In simplistic terms, Alaska's economic development has been one of boom-or-bust. Starting with the development of the fur trade in the mid-1800's, the economic health of this vast area has been tied to successive booms in gold, copper, fisheries, timber, and now oil.

The importance of Alaska to the nation and the national economy can be expressed in terms of defense considerations reflected in expenditures for personnel, procurement and construction and the gross value of products from natural resources which are exported from the State to other domestic markets or enter into international trade.

Prior to the 1942 invasion of the Aleutian Islands by the Japanese, Alaska's national importance was as a source of fishery products (for the most part canned salmon), gold, copper (for a brief period) and raw furs. During the 1931-40 decade, the average annual value of outshipments from Alaska was $58,758,000 composed of canned salmon (55.1 percent of total value), gold (26.6 percent), other fish products (6.4 percent), furs (4.4 percent), used machinery, scrap metal and other miscellaneous items.

From 1942 through the 1960's Alaska, from the national point of view, became primarily an exporter of military defense. Between 1951 and 1954, while the DEW line and other facilities were under construction, spending by the Department of Defense in Alaska averaged $412.9 million annually.

During the 1960's amounts fluctuated between $264.6 million (1962) and $352.0 million (1968).

Statistics on Federal spending in Alaska for national purposes and the total value of resource production give an impression of Alaska's economic importance to the nation, but they do not present a true picture of the Alaska economy. Much of the construction and procurement expenditures of the Department of Defense never entered the resident economy because much of the equipment, supplies, and specialized labor force must be imported. A great deal of the total value of natural resources likewise escaped the resident economy in the form of profits and interest to nonresident corporations and investors, in equipment and supplies purchased outside Alaska, and transportation costs and seasonal wages paid to nonresident workers.

The gradual economic maturation of the State is reflected in the rural to urban intra-Alaska migration. More than 61% of the States's population is concentrated in three major areas: Anchorage, Fairbanks, and Juneau. The Anchorage area currently has almost one-half of the State's population; it is becoming a manufacturing and service center for the entire State. Fairbanks has become the commercial and trade center for the central and northern regions of the State. Juneau, the present State capital, has increased in importance as State expenditures become a larger part of the Alaskan economy in relation to Federal monies.

The Alaskan electorate voted in 1974 to move the State capital to an interior location which has not yet been selected.

Economic Activities--Commercial fishing for salmon, halibut, and herring began in Alaska during the late 1800's. Fishing for shrimp, crab, and clams began in Alaska about 1920, and shellfish products have now become the State's second most valued seafood after salmon. Overall, Alaska produces 10 to 12 percent of the total value of U.S. fisheries products.

Fish processing provided the bulk of manufacturing activity in the years prior to Statehood. Employment fluctuates yearly (and seasonally) with from 8,000 to 11,000 persons finding employment in some 200 plants.

Alaska's annual harvest of timber has increased steadily over the last 20 years to a present figure of over 650 million board feet per year, with an end product value exceeding $120 million.

Alaska exports over 70 percent of its forest products output, and over 90 percent of the export goes to Japan (NBA, 1974).

Tourism in Alaska is a major industry with tourist numbers increasing at an annual rate of 15 percent for the past 10 years. Tourist expenditures have increased even faster so that an estimated 215,000 persons spent an estimated $72 million in 1973. The tourist trade that year accounted for about $10.5 million in State revenues.

Catering to tourists is a very labor intensive operation and tourist dollars have higher multiplier effects on Alaska's economy than most other types of industrial transactions. Thus, a relatively large share of tourist dollars tends to remain in Alaska's economy after the first transaction.

Miners and minerals have played a major role in Alaskan history. Hard rock miners were producing copper and gold from the coastal areas of the Alaskan Peninsula, Prince William Sound and Southeastern Alaska before the

Klondike gold rush in 1898-99. Petroleum has dominated mineral industry statistics since Statehood (1959) and demand for construction aggregates, sand, gravel, and stone has produced the second largest mineral product value.

The State contains large deposits of coal, iron, copper and nickel which have not been developed.

The oil and gas industry became a significant element in the economic activities of the State in the late 1950's with systematic exploration and development of the Upper Cook Inlet basin. Associated with the Upper Cook Inlet production area is a small chemical processing industry. Collier Carbon and Chemical Company, a subsidiary of Union Oil Company of California, produces ammonia and urea. A liquified natural gas (LNG) plant, two small refineries (Standard Oil and Tesoro-Alaskan), and an asphalt plant comprise the present complex. LNG is shipped to Japan and a Japanese firm is associated with the fertilizer plant. The two refineries produce heating oil and jet fuel for local consumption with a combined throughput of 51,000 barrels of oil daily. Crude gasolines are either shipped to California for further refining or blended with imported petroleum products to produce motor fuels.

With start of intensive oil development at Prudhoe Bay in 1969, a marked shift in statewide emphasis took place from the Cook Inlet to the North Slope and from Anchorage to Fairbanks. Tussing, Rogers and Fischer (1971) stated:

> ...the long term impact of North Slope oil will come mainly from production revenues. It is not correct, therefore, to attribute all or most of the projected growth to the proposed oil pipeline as such; the bulk of the gains to the State would occur whatever route were chosen to transport the crude oil to markets...

Oil from the Prudhoe Bay field is scheduled to start moving through the trans-Alaska oil pipeline system in 1977.

Employment--The recent economic effects upon Alaska from the Alyeska construction effort are not fully considered because their full impact is just now becoming apparent.

Alaska's principal industry is government--the federal military and civilian establishment in the state, plus state, borough, and local jurisdictions. In 1970, nearly 46 percent of the personal income received by Alaskan residents originated in the government sector (ISEGR, 1971). The next largest sector was wholesale and retail trade, with 11.6 percent. The State's natural resources--minerals, forest, agriculture, and fisheries--accounted collectively for about 5.9 percent of total personal income, and the processing and manufacturing of products from these primary sectors added only another 5.3 percent.

Civilian government employment has accounted for a steady 34 percent of total employment since 1970. Federal employment has been declining steadily, however, with state and local government employment expanding to compensate.

Between 1970 and 1973, federal civilian employment declined, relatively, from 48.0 percent to 41.0 percent of total government civilian employment. The level of government civilian employment rose in the same period from about 35,600 to 49,900 persons (Department of Economic Development, 1973).

Defense spending is the largest single component of federal expenditures in the state. In the fiscal year 1970, military expenditures amounted to $346.3 million, equivalent to 43.6 percent of total spending. Military cutbacks in operations, maintenance and total military spending continued to rise to $435.1 million in 1973, the highest level of military expenditures since construction of the DEW Line between 1951 and 1954.

In coming years federal employment and spending will remain a very important factor in the State's economic growth, but state and local government activities will assume an increasing share of total economic activity. Federal revenue sharing, program grants and native settlement claims payments together with the state and local government's income from production and property taxes on oil and gas operations will fund a rapid expansion of government employment and spending.

The study area civilian labor force is projected to expand from the 1970 level of about 15,500 persons to between 25,000 and 30,000 persons by 1975, the peak year of Alyeska pipeline construction employment, and around 32,500 persons by 1977. (Human Resources Planning Institute, 1974). The 1977 level is expected to hold constant until about 1980, when the long-term growth trend of the Alaskan economy is projected to manifest itself again.

Apart from petroleum production, the expansion of commodity production in the state is not expected to be rapid. Fishing, forestry, and hard metal mining may or may not expand, depending on market and supply conditions. The difficulties of climate (which introduce a high degree of seasonality in production and employment) and variability of markets inhibit the inflow of capital for investment in these sectors.

Construction, trade, transportation, and business and personal services will surely expand in step with petroleum development and government spending, and will provide some stabilization to seasonal variations in income and employment.

Projections of income levels as of 1977 are very uncertain, in terms of current dollars, because of different goods and services. On the basis of projected changes in employment (170,000 civilians employed in 1977 compared to 104,900 in 1970, based on a 1977 civilian labor force of 190,000 and an unemployment rate of 10 percent), and assuming that: (a) real (uninflated) wages rise by an average of three percent per year, and (b) the proportions of income components remain constant, then by 1977 the projected level of aggregate personal income would amount to about $2.6 billion, compared to slightly less than $1.3 billion in 1970 (both in 1970 dollars).

Income distribution is highly skewed in Alaska because of the relatively large number of Natives living outside or at the margin of the cash economy. Reviewing data from the 1970 census, it is evident that per capita income levels have a high and inverse correlation with the percentage of Natives in the population of a census division. Significantly, of the ten census divisions with Native population accounting for more than half of the total population, all but one (Upper Yukon) had per capita income levels below $2,650 (The Upper Yukon value reflects the inclusion of 200 or more oil field technicians at Prudhoe Bay at the time of the census). This compares to the statewide average of $3,765 per person. The remaining 19 predominantly Caucasian census divisions were closely grouped around the statewide average. Over time, it is expected that increased employment opportunities for Natives growing out of the oil pipeline project and the Alaska Native Settlement Claims Act will tend both to close the income gap between Natives and non-Natives and to raise the overall level of income and well-being. Table (8.2.1.-11) relates economic activities to total population.

Table 8.2.1-11 Alaska: estimated population and employment, 1961-1973[1]

	1961	1970	1972	1973
Total Population (July 1)	236.7	304.6 2/	324.4	330.3
Total Civilian Work Force	75.5	114.8	131.3	137.8
Rate of Participation 3/	31.9%	37.7%	40.5%	41.7%
Total Unemployment	7.5	9.9	13.7	14.4
Percent of Civilaim W.F.	9.9%	8.6%	10.4%	10.4%
Total Civilian Employment 4/	68.0	104.9	117.6	123.4
Self-employed, Agriculture, Family Worker, etc.	10.8	12.4	13.5	13.6
Government (Civilian)	23.8	35.4	40.5	41.9
Federal	15.6	17.0	17.2	17.3
State & Local	8.2	18.4	23.3	24.6
Mining	1.2	3.0	2.1	1.9
Contract Construction	4.1	6.9	7.9	8.2
Manufacturing	5.3	7.8	8.1	8.9
Distributive	22.7	38.1	45.6	48.8
Trans., Comm. Public Util.	7.2	9.1	10.0	10.4
Trade	8.1	15.4	17.1	18.2
Finance, Inc., Reat Estate	1.5	3.0	3.7	4.1
Services & Miscellaneous	5.9	11.6	14.8	16.1

1/ All work force and employment = 12 month average, in thousands of persons, for calendar year.

2/ Final 1970 Census Estimate adjusted to July 1, 1970.

3/ Rate of participation = Total Civilian Work Force divided by Total population.

4/ The Total Civilian Employment may not equal the sum of individual industry employment figures due to rounding.

Source: Dep. of Labor, 1974.

Native Subsistence--The communities of Wiseman, Evansville/Bettles, Stevens Village, Minto, Gulakana and Copper Center are the native villages that would be encountered along this route. The inhabitants of these villages depend, for the most part, on the natural resources of the area for their subsistence. Those villages that are served by ground transportation are trending toward a cash based economy but this is not the dominant means of subsistence at this time.

Income--Income levels in the Interior area vary widely. In the Fairbanks metropolitan area, per capita income levels exceed the statewide average, owing to the relatively high concentration of managerial, administrative and professional occupations, and the low concentration of Native settlements. In 1970, the Fairbanks Census Division had a per capita income level of $3,982. With the concentration of Alyeska pipeline project supervisory and logistical functions to develop in Fairbanks between 1974 and 1977, and the stimulus to local trades of project employee recreational visits, the average income level should rise considerably during the project years. Local prices will also rise, however, eroding much of the real increase in purchasing power.

Away from Fairbanks and the small number of communities located in the oil pipeline corridor (the extended effect zone), average income levels are considerably lower. This is to be expected, because there are no significant urban concentrations outside the corridor and because most communities in the Interior are small, predominantly native villages. State and local social and economic development programs and the earnings of local Natives gaining employment on the pipeline project will bolster incomes, but major gains will probably not be realized until well after the Alyeska project is completed.

The value indicated in Table 8.2.1.-12 for income crude petroleum and natural gas production ($49 million) seriously understate the value of production. Value added in the state to petroleum production includes not only profits accruing to Alaskan owners (shareholders) of oil properties (estimated at approximately 10% of value added), but also of net payments of non-residents, depreciation and depletion, royalties and other leasehold payments to state and federal governments, production taxes and corporation and other business taxes. The ISEGR study (1971) estimates that in 1969 total value added in crude petroleum and natural gas amounted to $460 million.

Subsistence--Subsistence must be assessed in two strata; remote villages and villages served by existing ground transportation. Along this alternative route this change occurs at about the Yukon River. North of the Yukon:

Data on subsistence harvest is available for two villages near the route. According to the NANA Regional Corporation survey (1973) harvest was as shown in Table 8.2.1.-13.

It may be assumed that monetary cost of commodities to replace subsistence harvest would be between $600 and $1,000 per person per year based on Anchorage prices of corresponding goods and transportation charges. South of the Yukon:

There are no corresponding data for subsistence harvest of villages along the Alaska Highway. It is assumed to be less, although still significant, for two reasons. Commodities may be transported much cheaper by truck than by air which is the required mode north of the river.

Table 8.2.1-12 Industrial sources of personal income in Alaska (1970)

	Personal Income Originating in Named Industry	
	millions of current dollars	percent of total
Farms	1	.1
Fishing	21	1.6
Mining	54	4.2
Coal mining	1	.1
Crude petroleum and natural gas	49	3.8
Other mining	3	.2
Contract construction	119	9.2
General building contractors	36	2.8
Highway and heavy construction contractors	61	4.7
Special trade contractors	22	1.7
Manufacturing	68	5.3
Food processing	18	1.4
Logging, lumber, and pulp	17	1.3
Chemicals	3	.2
Other retail trade	30	2.4
Wholesale and Retail	150	11.6
Wholesale trade	32	2.5
Eating and drinking places	27	2.1
Other retail trade	91	7.1
Finance, Insurance, Real Estate	35	2.7
Banking	14	1.0
Other Finance, Insurance and Real Estate	21	1.6
Transportation, Communications Public Utilities	120	9.3
Railroad transportation	6	.4
Highway freight and warehousing	20	1.6
Water transportation	9	.7
Air transportation	38	3.0
Other transportation	4	.3
Communications	33	2.6
Electric, gas and sanitary services	10	.8
Services	130	10.1
Hotels and other lodging places	10	.8
Personal services	10	.8
Business services	24	1.9
Repair services	5	.4
Amusements and recreation	3	.2
Professional, social and related services	74	5.7
Government		
Federal military		
Federal civilian		
State government		
Local government		
TOTAL		

Sources: ISEGR, 1971a, p. 35.

Table 8.2.1-13 Estimated useable weights 1/ (in pounds) of subsistence harvest and average per capita consumption

Resources Harvested	Anaktuvuk Pass	Evansville Bettles
Mammals	153,695	27,765
Fish	3,500	1,150
Wildfowl	900	210
Berries	400	850
Greens/Roots/Vegetables	--	540
TOTALS	--	540
Current Resident Native Population July 1973 2/	123	21
Per Capita Resource Consumption	1,298	1,500

1/ For mammals, wildfowl, and fish, figures are based on estimates of dressed weight for each resource. For berries, greens/roots/vegetables gross weights of harvest are given.

2/ Based on Alaska Native Enrollment - Summary 1973. U.S. Department of the Interior, Bureau of Indian Affairs.

Secondly, also due to the highway, there are greater opportunities for cash employment.

Sociological Factors

Population--Alaska population in the 1970 census was 302,361 (Department of Commerce). Normal growth plus Alyeska pipeline stimulated influx yields a 1974 estimated population of 357,000. By 1977 it is projected that statewide population will be 426,000.

Tables 8.2.1.-14 and 15 display these data with particular emphasis on these alternative route segments.

By 1977, the projected base year for initiation of on-site construction activities for the gas pipeline, the Aleyska oil pipeline will have been largely completed. The temporary burst of oil pipeline employment will have largely receded, but will have left a significantly increased level of permanent populations and employment.

Table 8.2.1.-16 indicates, to the extent of available data, ethnic strata within the population. Additional, more generalized, population data are provided in Table 8.2.1.-17 which amplifies on sex and ethnic derivation. Finally, Table 8.2.1.-18 presents age characteristics for selected portions of the route.

Government--The North Slope Borough is discussed in Chapter 2 of the Alaska Volume. That section also discusses Kaktovik, the organization of which is typical for a Native village.

Fairbanks, and the associated North Star Borough is Alaska's second largest metropolitan area. Fairbanks was incorporated in 1903 and operates under a city council utilizing a professional city manager.

Delta Junction, a second class city incorporated in 1960, is the only other non-traditional, i.e. tribal, community along the route.

Education--The striking point about the education profile along this route is the percentage of persons completing high school or some college. Fairbanks and Southeast Fairbanks compared with other parts of the state.

Table 8.2.1.-19 illustrates the contrast. These data reflect both the impact of the military personnel and the urban setting of Fairbanks on area educational characteristics. The Upper Yukon Census Division is the only census division in the Interior which reports perceptively lower educational values than the other divisions in the area.

Fairbanks is the home of the University of Alaska and in addition, has a community college which stresses vocational skills.

Health--Health care in the Interior Region centers around Fairbanks. The military health service and the civilian health system are most developed in Fairbanks (Mathematical Sciences Northwest, Inc., 1972). Military personnel who numbered approximately 15,000 in 1970, will most likely continue to use the military health service system which will expand or contract as required.

Table 8.2.1-14 Baseline population projections for route segments, 1970-1977

Segment	1970	1974	1977
Arctic	3,000	4,300	5,400
Interior	52,600	57,200	66,200
South Coastal	130,080	170,000	209,000
Other	116,681	125,700	145,400
Alaska Total	302,361	357,200	426,000

1/ Arctic includes the northern part of the Upper Yukon Census Division and all the Barrow Census Division.

2/ Interior includes the southern part of the Upper Yukon, the Fairbanks and Southeast Fairbanks, and the northern one-half of the Valdez-Chitina-Whittier Census Divisions. The portion of the Valdez Census Division included accounts for communities in the Copper River Valley (Gulkana, Glennallen, Copper Center, etc.).

Note: The above tabulation based on Alaska Department of Commerce data, Alyeska project's population impact; the data indicate the historical and projected annual rates of growth of the State's population since 1960:

Period	Average Annual Rate of Growth (%)
1960-1970 (actual)	2.95
1970-1974 (estimated)	4.25
1974-77 (projected)	6.05

Table 8.2.1-15 Baseline populations for census divisions, 1970-1977

Place	1970[1]	1974[2]	1977[3]
Northwest	13,181	14,600	16,500
Barrow	2,663	2,600	4,000
Kobuk	4,434	4,500	4,900
Nome	5,749	5,800	6,200
Northern Upper Yukon[3]	335	1,700	1,400
Interior	56,144	60,700	69,000
Southern Upper Yukon[3]	1,349	1,700	1,700
Fairbanks	45,864	49,000	56,200
Southeast Fairbanks	4,179	4,500	5,100
Yukon-Koyukuk	4,752	5,500	6,000
Southcentral	163,792	206,000	254,000
Cordova-McCarthy	1,857	2,000	2,500
Valdez-Chitina-Whittier	3,098	5,000	10,200
Matunuska-Susitna	6,509	8,000	8,600
Kenai-Cook Inlet	14,250	14,100	17,800
Kodiak	9,409	9,500	12,400
Seward	2,336	2,500	3,000
Anchorage	126,333	165,000	199,500
Southwest	26,679	26,500	29,000
Wade Hampton	3,917	3,900	4,300
Kuskokwim	2,306	2,300	2,500
Bethel	7,767	7,600	8,300
Bristol Bay	4,632	4,600	5,100
Aleutian Islands	8,057	8,100	8,800
Other	42,565	49,300	57,500
Alaska	302,361	357,200	426,000

1/ Dept. of Commerce.

2/ Dept. of Labor, 1974 (mid-year).

3/ The Upper Yukon Census Division has been divided into a Northern Section (North of Brooks Range) and a Southern Section. Thus, Kaktovik, Deadhorse, and Prudhoe Bay are in the Northern Upper Yukon Sector, while such communities as Fort Yukon, Stevens Village, and Evansville (Bettles) are in the Southern Upper Yukon Sector.

Table 8.2.1-16 Communities, population and Native enrollment along the trans-Alaska route

Community	1970 Census			ANCSA 1/ Native Enrollment 1973	Total Current Population Estimate
	Native	Non-Native	Total		
Anaktuvuk Pass	97	2	99	135	125
Fairbanks and vicinity	1818	44,046	45,854	2/	49,000
Delta Junction	10	693	703	2/	730
Evansville (Bettles Field)	14	43	57	76	80
Mentasta Lake	64	4	68	104	65
Northway	10	30	40	203	192
Stevens Village	72	2	74	173	56
Tanacross	77	7	84	150	97
Tetlin	108	6	114	113	107
Tok	26	188	214	12	274
Wiseman	---	---	0	49 2/	unk

1/ Natives must enroll in a particular village, not necessarily current place of residence, to receive benefits under the Alaska Native Claims Settlement Act.

2/ Not an authorized Native village for ANCSA purposes.

Table 8.2.1-17 Race and sex of selected census divisions and villages, 1970

Census Division and Place	White		Indian		Aleut		Eskimo		Other		Sex[1/]
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Ratio
Barrow	216	114	6	4	1	0	1,192	1,110	18	2	116.5
Barrow	109	82	4	4	1	0	975	921	6	2	108.5
Anaktuvuk Pass	1	1	0	0	0	0	55	42	0	0	130.2
Upper Yukon	484	104	488	419	5	2	98	65	16	3	184.0
Prudhoe Bay	45	0	0	0	0	0	4	0	0	0	N.C.[2/]
Kaktovik	10	5	0	0	0	0	65	44	0	0	146.0
Deadhorse	148	0	2	0	0	0	13	0	0	0	N.C.
Stevens Village	2	0	44	28	0	0	0	0	0	0	164.3
Cordova-McCarthy	858	671	21	28	121	102	5	7	21	23	123.5
Cordova	537	431	10	13	70	62	3	4	16	18	120.5
Meakerville	143	112	9	11	40	30	0	0	1	3	123.7
Valdez-Chitina-Whittier	1,309	1,069	212	201	105	73	61	49	13	6	121.6
Chistochina	7	9	7	10	0	0	0	0	0	0	73.7
Chitina	20	12	2	1	0	0	2	1	0	0	171.4
Copper Center	60	49	55	36	0	0	0	0	4	1	136.78
Gakona	34	31	8	13	0	0	0	2	0	0	91.3
Glennallen	163	163	11	14	2	1	4	5	0	0	98.4
Gulkana	1	0	31	21	0	0	0	0	0	0	152.4
Tatitlek	2	2	0	0	64	43	0	0	0	0	146.7
Valdez City	431	417	13	22	38	26	33	18	3	4	106.4
Fairbanks North Star	23,599	17,334	491	529	33	21	336	466	1,885	1,200	134.6

Table 8.2.1-17 (cont.)

Census Division and Place	White		Indian		Aleut		Eskimo		Other		Sex Ratio [1/]
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	
Southeast											
Fairbanks	2,054	1,364	241	248	2	2	8	12	157	101	143.4
Delta Junction City	350	312	3	1	0	0	2	1	17	17	112.4
Fort Greely	1,058	518	5	6	0	0	1	8	136	78	198.4
Anchorage	59,231	53,734	853	922	355	403	1,001	1,282	3,701	3,081	109.6

1/ Sex Ratio = Number of males divided by number of females times 100.

2/ N.C. = not computed.

Sources: ISEGR, 1972a, 1972b

Table 8.2.1-18 Age characteristics of selected census divisions and villages, 1970

Census Division and Place	Persons 15 Years and Younger		Persons 60 Years and Older		Persons Between Ages 15 and 60 Years		Demographic Dependency Ratio
	Number	%	Number	%	Number	%	(DDR)1/
Barrow	1,132	42.5	122	4.6	1,409	52.9	89.0
Barrow	1,012	48.1	91	4.3	1,001	47.6	110.1
Anaktuvuk Pass	45	45.5	6	6.0	48	48.5	118.6
Upper Yukon	511	30.3	124	7.4	1,049	62.3	60.5
Prudhoe Bay	0	0.0	1	2.0	48	98.0	2.0
Kaktovik	46	37.4	9	7.3	68	55.3	80.8
Deadhorse	0	0.0	1	0.6	162	99.4	0.1
Stevens Village	28	37.8	5	6.8	41	55.4	80.5
Cordova-McCarthy	645	34.7	148	8.0	1,064	57.3	74.5
Cordova	397	34.1	99	8.5	668	57.4	74.2
Meakerville	136	39.0	16	4.6	197	56.4	77.3
Valdez-Chitina-Whittier	1,038	33.5	206	6.6	1,854	59.9	66.9
Chistochina	13	39.4	2	6.1	18	54.5	83.5
Chitina	11	28.9	4	10.5	23	60.6	65.0
Copper Center	67	32.5	26	12.6	113	54.9	82.1
Gakona	38	43.2	1	1.1	49	55.7	79.5
Glennallen	147	40.5	7	1.9	209	57.6	73.6
Gulkana	15	28.3	6	11.3	32	60.4	65.6
Tatitlek	49	44.1	5	4.5	57	51.4	94.6
Valdez City	322	32.0	53	5.3	630	62.7	59.5
Fairbanks North Star	14,863	32.4	1,149	2.5	29,852	65.1	53.6

Table 8.2.1-18 (cont.)

Census Division and Place	Persons 15 Years and Younger		Persons 60 Years and Older		Persons Between Ages 15 and 60 Years		Demographic Dependency Ratio
	Number	%	Number	%	Number	%	(DDR)[1/]
Southeast Fairbanks	1,365	32.7	133	3.2	2,681	64.1	56.0
Delta Junction City	12	30.3	9	1.3	481	68.4	46.2
Fort Greely	529	29.1	8	0.4	1,283	70.5	41.8
Anchorage	44,966	36.1	3,450	2.8	76,126	61.1	63.7

[1/] Demographic Dependency Ratio (DDR) is the number of persons under 15 and over 60 divided by the number of persons between 15 and 60 multiplied by 100.

Source: ISEGR, 1972a.

Table 8.2.1-19 Educational characteristics of selected census divisions, 1970

Census Division	Not Completing Any Years of School	Years of School Completed (Percentage of Population) Elementary School 1-4 yrs.	5-7 yrs.	8 yrs.	High School 1-3 yrs.	4 yrs.	College 1-3 yrs	4 Yrs. or More
Barrow	15.1	17.3	26.8	13.3	8.4	9.0	3.6	6.5
Upper Yukon	11.4	13.6	12.7	11.3	11.9	20.0	12.6	6.5
Fairbanks	0.7	1.0	2.6	5.6	15.2	41.9	16.4	16.6
Southeast Fairbanks	3.6	2.0	7.8	8.1	15.6	33.9	14.7	14.3
Valdez-Chitina-Whittier	7.1	4.4	6.0	9.6	16.3	38.4	8.3	9.9
Cordova-McCarthy	0.5	4.4	7.0	6.5	18.8	34.8	18.1	9.9
Anchorage	0.5	0.9	2.8	5.5	14.4	42.7	17.4	15.8

Source: Reproduced from Table 2a.7-18.

The civilian health system, and its physicians, nurses, and hospitals, will be reasonably adequate except during the peak of the oil pipeline construction (Mathematical Sciences Northwest, Inc., 1972) which will have declined by 1977. It is possible, however, that by 1977 there will be a need for additional doctors because of projected continued strong growth. It is also estimated (Mathematical Sciences Northwest, Inc., 1972) that Alaska will need 2000 beds by 1980 to handle the 2.24 bed days of utilization per thousand projected for that year. It is possible that hospitals in Fairbanks and Anchorage may be able to meet the need for additional beds by 1977 when expansion of facilities catches up with poplulation changes induced by the Alyeska project.

Fairbanks also serves as a major regional center for health care. Commonly, persons in the Arctic, Upper Yukon, and Yukon-Koyukuk Regions will go to Fairbanks for hospitalization. Any increased load related to accidents and serious illness during the pipeline construction will fall mostly upon Fairbanks facilities.

Public Safety--Problems of law enforcement for areas in the Interior Region outside of Fairbanks are similar to those faced in other bush areas. The Alaska State Troopers must patrol a large area with too few troopers. By 1977 this condition will probably have been improved somewhat, in view of the state's improved financial condition.

Fairbanks has had an increasing crime problem. The crime rate has grown at a faster rate than the population (State of Alaska, 1974). Some of the reasons for the growing rate may be the increasing population density, changes in age, sex, and racial structure of the population, marital stability of the population, and climate. The increase in density means more impersonal interactions among people which may reduce the informal social norms governing deviant and criminal behavior. A decrease in the average age of the population, and a preponderance of males is also consistent with high crime. Young persons (the average age of persons in Fairbanks North Star Borough is 22.2 years) have higher crime rates than older persons, and males are involved in crimes more often than females (State of Alaska, 1974).

The ebb and flow of seasonal workers in the construction field and transients associated with military activities may also contribute to a high crime rate. A person is more likely to be involved in a crime when he is away from home. The transient population varies with the climate; however, the large extremes in weather conditions during the year and the increased night hours in the winter also influence the crime rate.

All of the above factors except climate will be influenced by the oil pipeline. It seems reasonable to assume that by 1977 the crime rate for Fairbanks will be greater than it is at present, but the magnitude of the increase is open to question. Assuming a "normal" ratio of one policeman to every 400 persons (State of Alaska, 1974) the Fairbanks North Star Borough will need about 140 policemen in 1977. This is a projected increase of 180 percent over 1974 levels, which will place strains on the existing organization and personnel with respect to the increased level of work and adminstration as well as financial requirements.

Land Use

Existing and Potential Land Use--Agriculture and forestry--Potential agricultural and range resources are located within the Copper and Chitina River valleys. Exploratory work by the Soil Conservation Service indicates

153,000 acres of good upland soil and 14,000 acres of bottom land along the Copper and Chitina Rivers near McCarthy, Strelna, Tonsina, Kenny Lake, and east of the Copper River from Gakona to Lower Tonsina. An additional 119,000 acres of hilly, sandy, or shallow soil is indicated in the general vicinity. A number of small areas with some agricultural potential are found near stream confluences. Narrow coastal strips and stream deltas along the coast might be grazed during the summers (Snodgrass, 1974).

Forestry potential in the Tanana valley section of the route is moderate. From Fairbanks east, stands of white spruce and birch have some commercial potential, though there is little present use, because of land status restrictions. There is high demand for timber from State lands in the area around Fairbanks.

Several small sawmills operate around Fairbanks and there is a mill at Delta Junction and another small operation between Delta and Tok.

Refer to Figures 8.2.1.-17a and 17b which shows areas considered as having potential for agricultural or commercial timber production.

In the Copper River Basin, the commercial forestry resource is restricted to the valley areas along the major rivers and streams. There are small, portable sawmills at Glennallen and Copper Center which make limited use of the forest resource. They operate on a part-time basis, primarily to process custom orders, often utilizing logs furnished by the customer.

Use and potential of coastal forest types are far different from that indicated above for the interior forest type. According to the United States Forest Service, the commercial forest in this unit is predominantly western hemlock. Sitka spruce is present in smaller amounts either in hemlock-spruce stands or in very small pure stands along creeks, rivers, or uplifted beaches. With the exception of Constantine Harbor, few large stands of spruce exist in the unit. The amount of mountain hemlock present increases towards Valdez Arm. Cottonwood is found scattered in several river bottoms, but is presently of no commercial value. Alaska yellow cedar is found in small amounts on Hawkins Island and scattered along the hillsides above Sheep and Gravina Bays.

The Hemlock-spruce type is at its extreme northern limit in the stands within Prince William Sound. Because of this northern location in a somewhat harsh climate, tree size and quality is low compared to other coastal forests to the south. Stands are primarily old growth, with second growth resulting from early cutting for railroad construction, fisheries development, and mining exploration. Areas such as Sheep Bay, Irish Cove, and Simpson Bay had considerable cutting during the past fifty years. Cutting in Constantine Harbor dates back to the early 1800's for use at the old Russian fort of Nucheck.

The Eastern Prince William Sound Unit of the Chugach National Forest consists of approximately 661,000 acres extending from Port Valdez on the north to Orca Inlet, near Cordova, on the south. It includes the eastern mountains of Prince William Sound, as well as Bligh, Hinchenbrook, and Hawkins Islands. The unit is typical of Prince William Sound, except that it has no big ice fields and only relatively small mountain glaciers.

Access to the unit is primarily by water transportation. There are no roads in the unit at the present time. It appears that most future timber harvest will utilize cable logging systems with some type of ground transportation to gain access into the areas not immediately adjacent to the water.

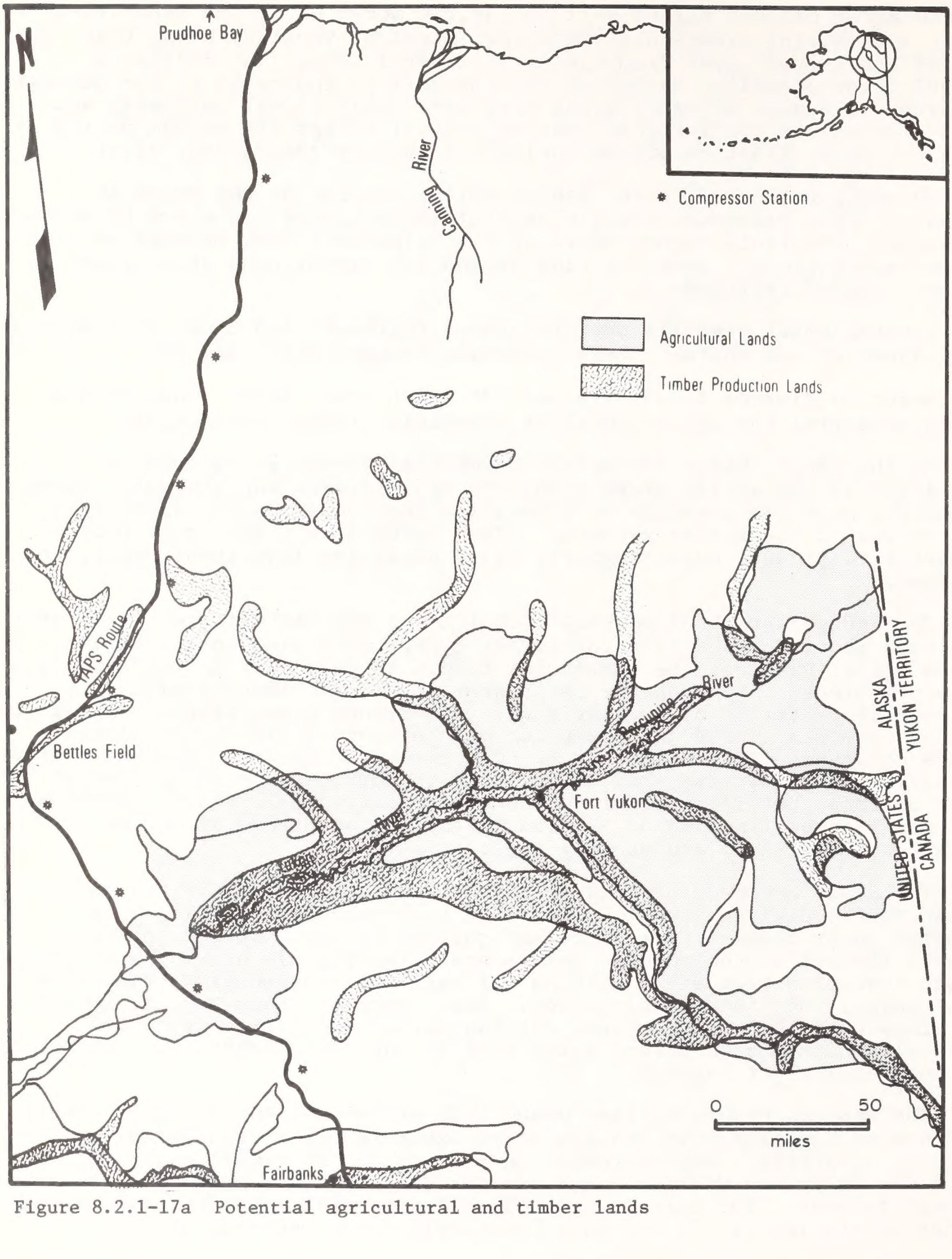


Figure 8.2.1-17a Potential agricultural and timber lands

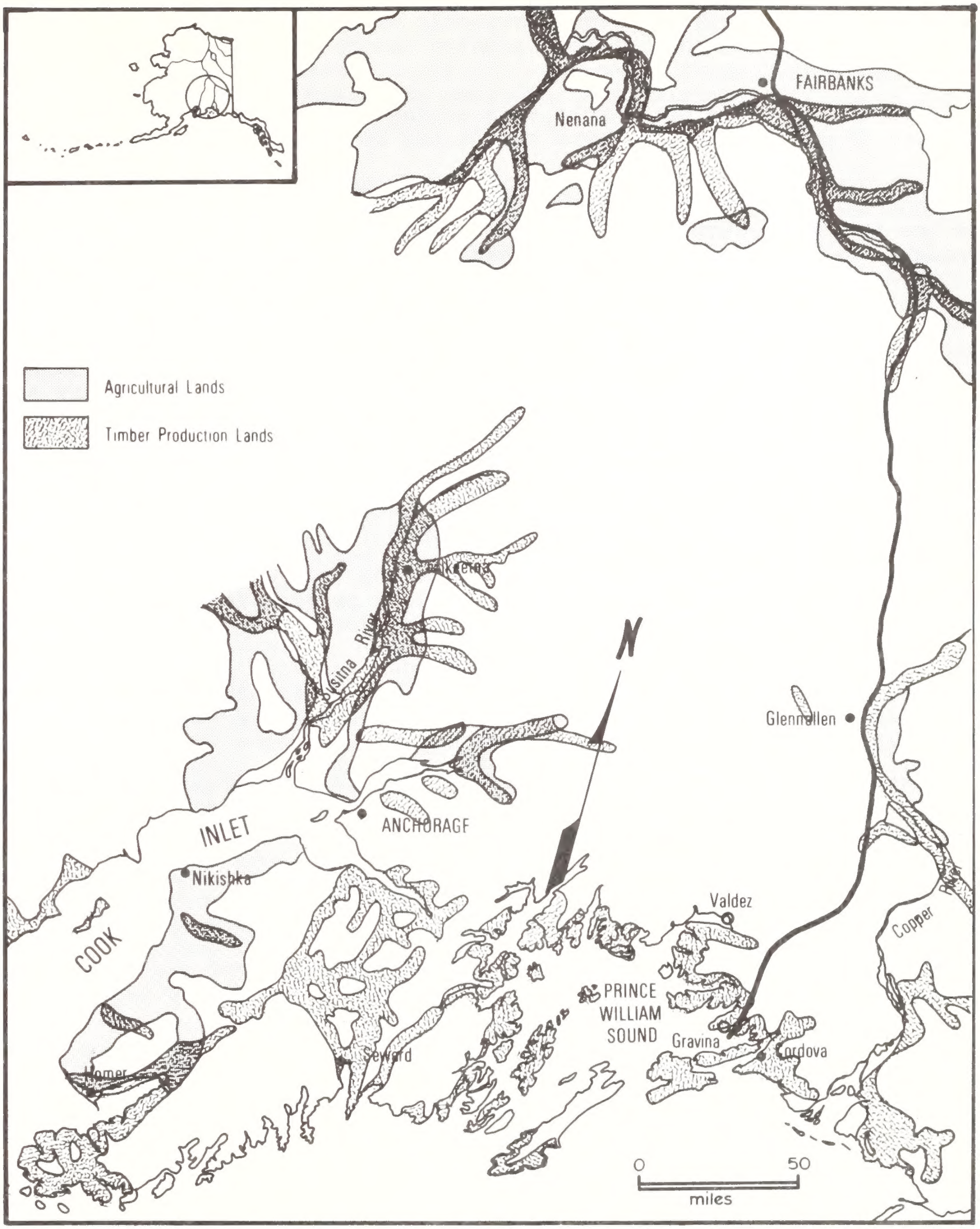


Figure 8.2.1-17b Potential agricultural and timber lands

Volumes per acre vary. Most presently operable stands are in the range of 25-35 MBF/acre. Stands in Port Fidalgo and on Hinchinbrook Island are somewhat larger.

Regeneration does not appear to pose any special problems; however, porcupine damage to second growth stands has recently been found.

Industrial--Since this alternative route parallels the trans-Alaska oil pipeline the entire route can be considered an industrial transportation corridor. The areas of intensive industrial development are limited to Prudhoe Bay, Fairbanks, and Valdez. Scattered along the route are various pumping stations and related facilities. There has been a proposal to develop a petroleum refinery at North Pole, near the city of Fairbanks.

Commercial Fisheries--There is no significant commercial fishery along this alternative except in Prince William Sound. Cordova and Valdez are home ports for the largest part of the Gulf of Alaska commercial fishing fleet. There are also commercial shrimp and crab operations in the Gulf of Alaska. Refer to the description of the marine environment for more information.

Residential Areas--At various points along this corridor, construction camps are being built for the Alyeska pipeline project, which will continue to be occupied for some time.

The Fairbanks area is the primary residential area along this alternative route. Low density urban areas near Fairbanks are spreading outward from the downtown area resulting in a suburban complex along all major roads.

Eastward from Fairbanks there are several small communities including North Pole, Delta Junction and Tok. Military installations along the route include Eielson Air Force Base and Fort Wainwright and Fort Greely.

Delta Junction (population 2,525); Gulkana (population 53); Gakona (population 88); Glennallen (population 625); Copper Center (population 206); Cordova (population 1,513), and Valdez (population 1,350) are the 8 other population nodes along the route (all figures 1970 census). Individual cabins, or small clusters, may be found intermittently all along the Richardson Highway.

Mineral Extraction--The principal areas of energy mineral crossed are the North Slope area south of Prudhoe Bay, and the smaller oil and gas provinces of the Middle Tanana near Fairbanks and the Copper River Basin near Glennallen.

Fairbanks was founded as a gold mining center. The mines are now generally considered to have been worked out.

In the Alaska Range, the route passes through a highly mineralized area, but no known production areas exist at this time. Nearly every stream crossed along the route is a potential gravel source area and many have been used. There are approximately 270 material sites along the Alyeska pipeline project, 65 on the Sagavanirktok River itself.

Transportation--Fairbanks is the road hub of interior Alaska. All major highways either originate or terminate there. In addition, it is the northern terminus of the Alaska Railroad. Fairbanks International Airport serves several major airlines. Pan American uses Fairbanks for refueling on its Circle Route flights. Fairbanks is also the major supply for air transport logistics to the North Slope.

Delta Junction is terminus of the Alaska Highway where it joins the Richardson Highway which connects Valdez and Fairbanks.

This route may cross the Yukon River on the highway bridge now under construction. The Yukon is navigable by shallow draft barges for four months of the year in the area. The water depth above Fort Yukon is a limiting factor at times. Maintenance of the Yukon River as an open transportation artery is the subject of an international treaty between the U.S. and Canada.

The route parallels the Tanana River from Fairbanks to Delta Junction. The Tanana River is navigable by barge for most of its length during the summer.

In addition to the Richardson Highway, the entire area is served by bush aircraft. Delta Junction, Glennallen, Valdez and Cordova receive scheduled air service.

Valdez and Cordova are on the Alaska Marine Highway (ferry) system, but not directly connected to Southeastern Alaska or the lower 48 States.

Transmission Facilities--There are no major utility networks north of Fairbanks. Several villages and small cities along the trans-Alaska pipeline route have independent facilities of their own. In the smaller villages, electricity is often provided by a privately-owned generator; such as in Cordova where power is generated via a local utility company.

Water distribution methods vary with the size of the community. Small villages do not have water distribution networks; they often draw their water from local lakes or a community well. Cities such as Cordova and Valdez have distribution systems which pipe water directly into individual dwellings.

Sewage is collected in honey buckets in the smaller villages. In the larger villages some have septic tanks. Conventional sewage systems are found only in the larger communities, such as Cordova.

Fairbanks, the second largest city in the state, has all the facilities one expects in a medium-size city of 45,000. Electricity, water supply, and sewage collections activities are carried on at a level in Alaska exceeded only in Anchorage.

All cities south of Fairbanks are linked by telephone with Anchorage. The villages do not have direct telephone communications, but rely on a radio-telephone system.

Land Ownership and Withdrawals--See Figures 8.2.1.-18a and 18b for land ownership Status.

The first sixty miles of this alternative route are within land owned by the State of Alaska. It then enters Federal lands and is contained within a utility corridor withdrawal. (PLO 5150 as amended). Near

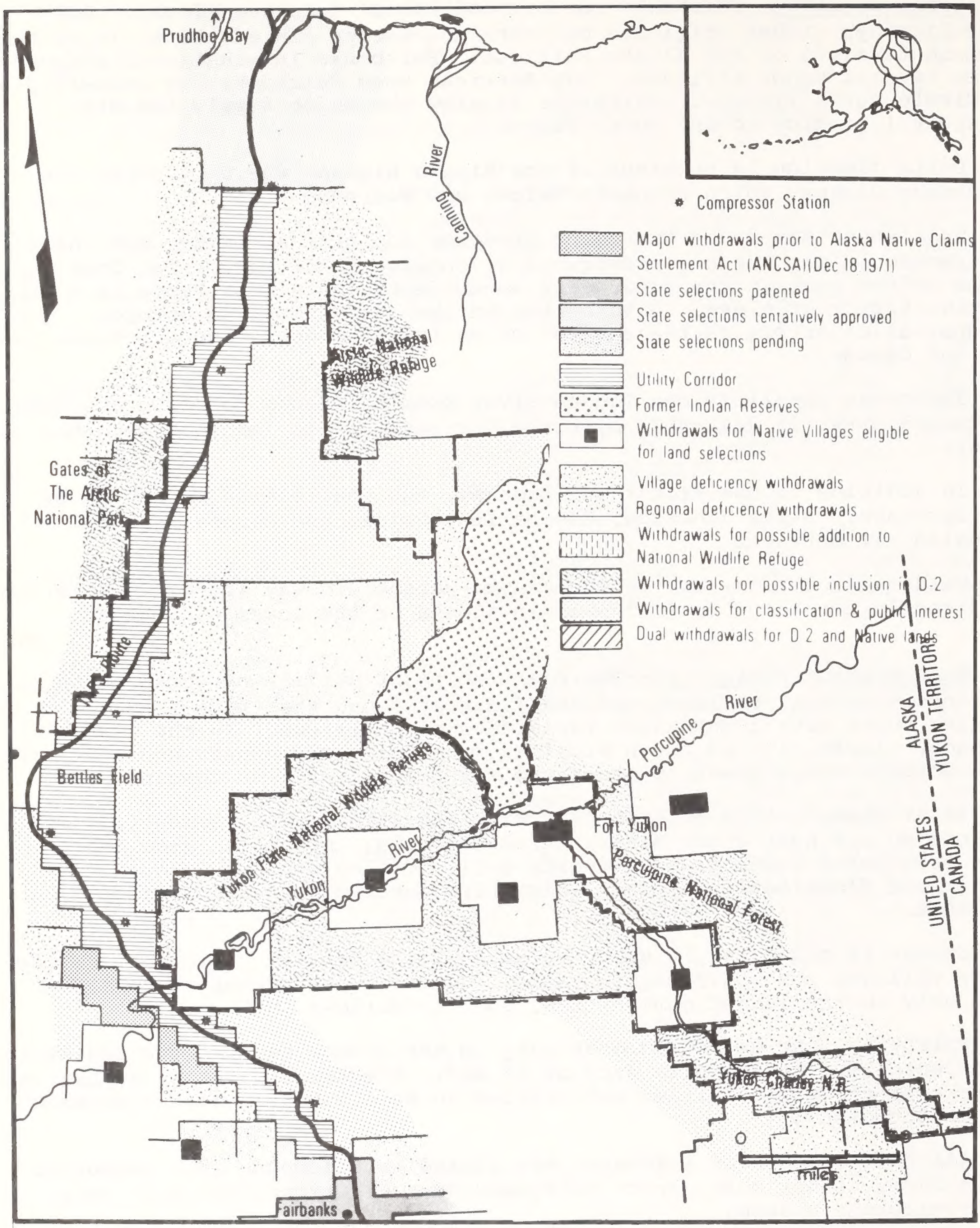
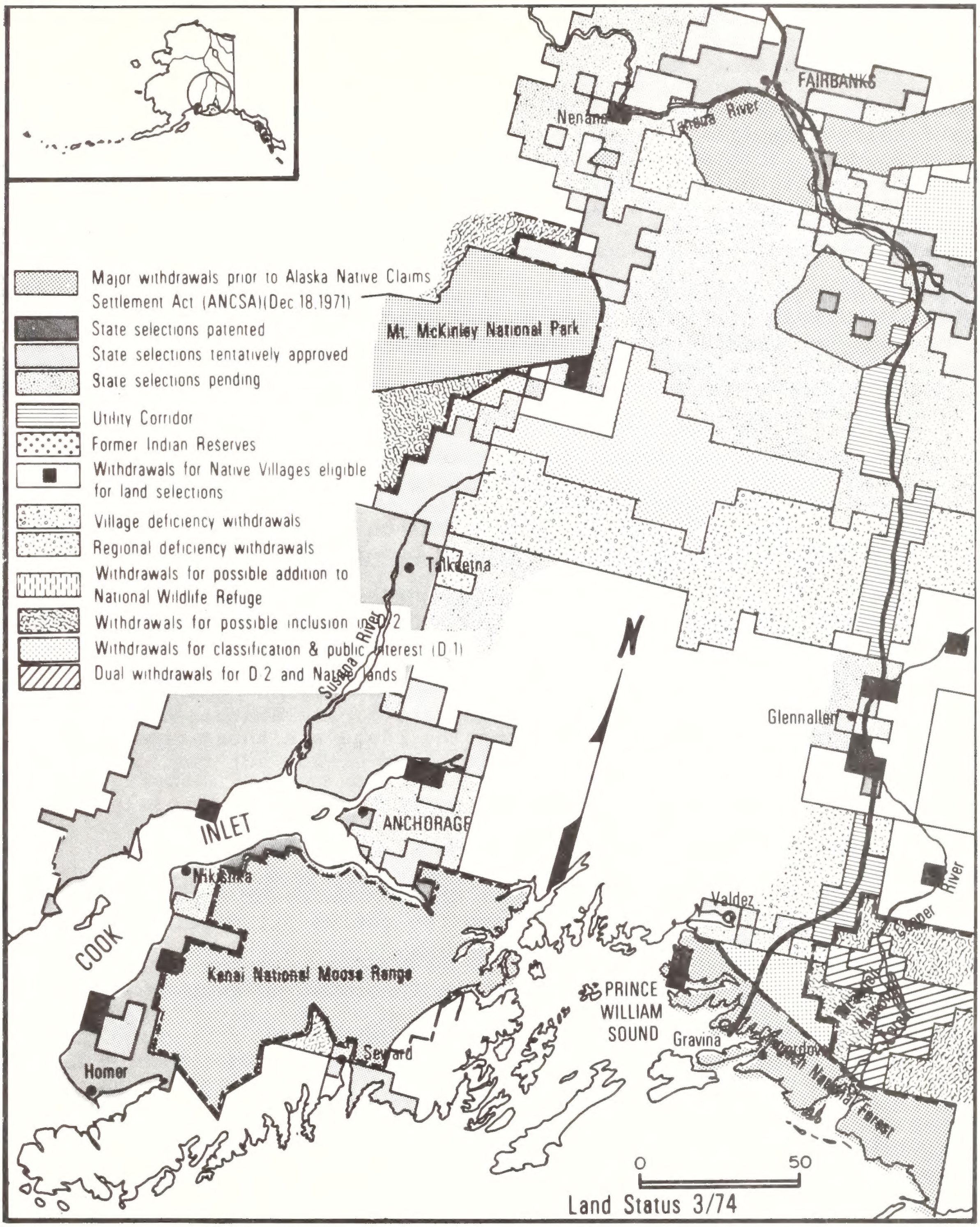

N
Prudhoe Bay
Canning River
Compressor Station
Major withdrawals prior to Alaska Native Claims Settlement Act (ANCSA) (Dec 18 1971)
State selections patented
State selections tentatively approved
State selections pending
Utility Corridor
Former Indian Reserves
Withdrawals for Native Villages eligible for land selections
Village deficiency withdrawals
Regional deficiency withdrawals
Withdrawals for possible addition to National Wildlife Refuge
Withdrawals for possible inclusion in D-2
Withdrawals for classification & public interest
Dual withdrawals for D 2 and Native lands
Arctic National Wildlife Refuge
Gates of The Arctic National Park
Haul Route
Bettles Field
Yukon Flats National Wildlife Refuge
Yukon River
Porcupine River
Fort Yukon
Porcupine National Forest
ALASKA
YUKON TERRITORIES
UNITED STATES
CANADA
Yukon Charley N.R.
miles
Fairbanks

Figure 8.2.1-18a Land status


Major withdrawals prior to Alaska Native Claims Settlement Act (ANCSA)(Dec 18,1971)
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Utility Corridor
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Withdrawals for Native Villages eligible for land selections
Village deficiency withdrawals
Regional deficiency withdrawals
Withdrawals for possible addition to National Wildlife Refuge
Withdrawals for possible inclusion in D 2
Withdrawals for classification & public interest (D 1)
Dual withdrawals for D 2 and Native lands
FAIRBANKS
Nenana
Tanana River
Mt. McKinley National Park
Talkeetna
Susitna River
N
Glennallen
ANCHORAGE
INLET
COOK
Nikishka
Kenai National Moose Range
Homer
Seward
Valdez
PRINCE WILLIAM SOUND
Gravina
Cordova
Copper River
National Forest
0
50
Land Status 3/74

Figure 8.2.1-18b Land status

Fairbanks the route enters an area owned by the State of Alaska, except for Eielson Air Force Base and Fort Greely which are withdrawn by the Federal Government for military purposes.

South from Delta Junction, the route passes through intermittent State and Federal ownership. The State lands have been selected but not patented and the Federal lands are within the corridor withdrawal. As the route approaches the Glennallen area, Native village ownerships are interspersed with State and Federal ownerships. As the route approaches the Keystone Canyon area near its southern terminus, it passes into State lands and then into National Forest land before reaching Gravina Point.

At this time, no land in Alaska is open to entry by settlement claim activity. A large number of prior existing settlement claim applications that are yet unperfected exist. As these claims are perfected, title of those lands will pass from the United States. Settlement claim activity within the Copper River basin centers around the community of Glennallen and the Kenny Lakes area.

In the Copper River Basin, the Native villages of Gulkana, Gakona, Tazlina, and Copper Center will be receiving title to land recently selected under jurisdiction of the Alaska Native Claims Settlement Act. Eyak Village Corporation has selected potential LNG sites on Prince William Sound, including Gravina Point and Hawkins Island under this Act.

The state and federal lands have one notable existing right-of-way, for the trans-Alaska oil pipeline. This right-of-way permit has been granted, and the construction permits are being issued to allow the use of areas along the pipeline for various reasons, such as campsites, waste disposal areas, and roads. In addition to these permits, various special land use permits and short-term leases of various natures are scattered along the route. The primary rights-of-way along the route are those granted by the Alaska Statehood Act that gave the State right-of-way for the existing Alaska and Richardson Highways.

Archeological, Historical and Unique Areas

Archeological Areas--The fact that the ancestors of some of Alaska's Eskimos and Indians occupied areas along the entire oil pipeline corridor has been well documented (Workman, 1972). The migrations of early man were made from Siberia, across the Bering Strait land bridge into Alaska. Hunters stalked their animal prey into the Interior and dwelled in the Brooks Range and elsewhere at a time when most of the rest of North America was still covered by glacial ice. Materials discovered at ancient caribou hunting sites reveal the existence of a people possessing a distinctive method of stone workmanship about five to seven thousand years ago.

The Final Report of the Archeological Survey and Excavations along the Alyeska Pipeline Service Company Pipeline Route was published in 1972. This massive comprehensive study resulted from more than two years of archeological survey, excavation, and analysis, which was carried out to preserve data from historic and prehistoric sites. In 1975, Humphrey et al. published A Study of Archaeological and Historic Potential Along the Trans-Alaskan Natural Gas Pipeline Routes. According to this study, the proposed corridor traverses important archeological areas between Prudhoe and Gravina. The portion spanning the Brooks Range is especially rich in terms of known archeological sites. The sites (approximately 100) discovered thus far along this segment of the TAPS alignment have revealed materials with cultural affiliations to Paleoindian, Paleoarctic Arctic Small tool and Eskimo Tool traditions and date from as early as 12,000 to 10,000 BC. Near the Yukon River sites indicate a cultural boundary between Early Eskimos and Early Athabaska. Relatively little archeological material is found in the Fairbanks vicinity. However, south of Delta Junction are numerous sites which represent some of the richest and most archeologically important in Alaska. These show cultural activities with other early complexes. At the southern end of the corridor sites have not been identified but other evidence strongly suggest that earlier occupation existed.

Historic Areas--Historic sites are recorded in the Alaska Heritage Resource Survey.

The Alaskan Interior contains numerous historic sites of the Gold Rush era. There are gold dredges, steamboat relics, saloons, courthouses, and houses of ill-repute. Many of these may deserve restoration and, possibly, reactivation, in their proper historical context. South of Fairbanks particularly, historical resources are abundant along the common route.

In the Brooks Range, above the Arctic Circle, lies the old mining center of Wiseman, which served as the supply center for gold miners in the central Brooks Range. Thirty old buildings remain intact in Wiseman. The Bureau of Land Management is presently preparing to nominate Wiseman to the National Register of Historic Places.

Roadhouses sprang up along all the major routes of travel in Alaska at about 15-mile intervals, offering meals and beds, often at exorbitant rates, to travelers in the primitive and harsh country between population centers. At one time, for instance, approximately 50 roadhouses lined the road between Valdez and Livengood. Most of the roadhouses are in states of disrepair or ruin today, although about 15 currently exist in either good or fair condition along that route.

Only the Sourdough Roadhouse had been entered in the National Register of Historic Places. Others on this segment worthy of consideration for National Register status and/or preservation include Poplar Grove Roadhouse (Mile 86, Richardson Highway), McCreary's Roadhouse (Mile 104, Richardson Highway), Gakona Roadhouse (Mile 132 Richardson Highway), Paxon's Roadhouse (Mile 191, Richardson Highway), Rapids Hunting Lodge (Mile 220, Richardson Highway), and Big Delta Roadhouse (Mile 252, Richardson Highway).

Unique Areas--There is one designated National Landmark on this route which is Worthington Glacier. The glacier is located about 30 miles northeast of Valdez on the Richardson Highway, and near the trans-Alaska oil pipeline route. The glacier is easily accessible from the highway and is a noted tourist attraction.

Several additional areas have been studied for possible designation as Natural Landmarks. The studies were contracted through the National Park Service and conducted by the Tundra Biome Center (University of Alaska), the Arctic Environmental Information and Data Center of the University of Alaska, the Lawrence Radiation Center, and Robert Detterman of the U.S. Geological Survey.

The sites are briefly described as follows:

Sagavanirktok River--This site is located on the Sagavanirktok River south of Prudhoe Bay.

Ivishak-Saviukviayak Rivers--These rivers are located 10 miles east of the Sagavanirktok River in the foothills of the Phillip Smith Mountains, these rivers are fed by springs throughout the year. Aufeis deposits are prevalent. The area was glaciated during the Wisconsin Age, and several moraines were left as the glaciers receded. Two areas along the Ivishak-Saviukviayak have been studied for designation as Natural Landmarks. One has significant glacial features, the other area will be recommended for designation because of its arctic river features.

Toolik River Plain--This plain is located between the Toolik and Sagavanirktok Rivers, twenty miles south of the Arctic Coast, this area is a significant example of an arctic coastal river alluvial plain. Three areas along the Toolik have been studied for designation as a Natural Landmark because of significant plain, river, and permafrost features.

Atigun Gorge--Located east of the Sagavanirktok River, 20 miles south of its confluence with the Ribdon River, this gorge is a steep-walled canyon cut by a Pleistocene glacier. The Atigun River, which heads in the Endicott Mountains, flows through the gorge. Exposed rock faces in the gorge date from the Mississippian Period. The area is very scenic.

Franklin Bluffs and White Hills--These areas are good badland areas similar to the Badlands of South Dakota. Many multi-colored rock faces have been exposed by erosion. The Sagavanirktok River and the oil pipeline already transect the study area.

Black Rapids Glacier--This glacier is an easily accessible example of a rapidly advancing and retreating glacier. It lies along the Richardson Highway about 120 miles southeast of Fairbanks.

Gulkana Trumpeter Swan Nesting Area--Lying northwest of Gulkana, bordered on the south by the Glenn Highway and on the east by the Richardson Highway, this area hosts one of the world's largest concentrations of trumpeter swans.

From studies conducted by the University of Alaska and several Federal agencies, the Joint Federal-State Land Use Planning Commission for Alaska recommended in 1973 that a systematic statewide analysis of nominated Science Research and Natural Areas be undertaken to develop a balanced and representative statewide system of such areas.

There are nine areas near this route which were nominated. These sites, progressing from north to south are described briefly below.

The Franklin Bluffs site (size not specified) is located on the Sagavanirktok River. These bluffs are a prime nesting area for the endangered peregrine falcon. Studies have been conducted in this area on falcons and fish by the State Department of Fish and Game, University of Alaska, and Canada. Much of the natural undisturbed bluff area is near the potential route through a narrow valley. The oil pipeline road and pipeline which is under construction pass along the west side of this canyon.

The Atigun Canyon site includes an unspecified area adjacent to the present road and oil pipeline which is being constructed through the Atigun Canyon. Its purpose is to provide a study area for natural and disturbed Eriophorum tundra, alpine and transition areas. A revegetation study is also underway. In 1970 and 1971 the University of Alaska conducted Dall sheep studies since this is an important lambing ground with one of the highest concentration of Dall sheep in the Brook Range.

The Galbraith Lake site is also close to the road and oil pipeline. It was established as a study area and has had Canadian and Alaskan fish studies conducted at it since 1969, revegetation studies since 1970, and University of Alaska archeological studies in 1970 and 1971. The purpose of this area is considered the same as the previously discussed Atigun Canyon.

The Dietrich River site is a 12-acre stand of riverbottom white spruce located at treeline. The elevation is 2,600 feet. The purpose is to preserve this unique stand. It is also near the road and oil pipeline which is now being built.

The Dolomites site has what is considered to be an unique dolomite outcrop located within the dedicated oil pipeline corridor. If this route were to be selected, there would need to be a field investigation to determine the exact route so that it would bypass the site.

The Fox Tailings site contain gravel spoils from the gold dredge operations near Fox and date back to the 1920's and 1930's. They are considered to provide an unusual opportunity for the study of progressive weathering, soil formation, and plant succession on surfaces with known age disturbance. At present many of the tailing piles are being destroyed as Fairbanks urban growth encroaches on the areas and as tailings are used as a gravel source for construction.

The existing Shaw Creek Experimental Area covers 40 acres with a suggested expansion to 1,000 acres. No research is in progress, but studies concerning paper birch seed production in a 95-year old stand and white spruce establishment in the paper birch type were conducted in the past. It is located in gently rolling topography at an elevation of approximately 1,120 feet.

The Black Rapids Glacier area of unspecified size is a classic example of a glacier subject to intermittent surges (very rapid and sudden advances). It exhibits ice-covered moraines, trimlines, and older moraines dating from the past few centuries.

The Worthington Glacier area also of unspecified size, is an example of a small valley glacier in a mountainous area of Alaska. The site includes fine examples of most features of a glacier from accumulation area to end moraine. It has the additional advantage of being very accessible.

Esthetics and Recreation Resources

Esthetics and Wilderness--North of the Yukon River all areas, with the exception of oil production and transmission facilities, are essentially wilderness. This is not to say that man's impact has been totally absent, but it has been localized. Historically, man occupied villages and from such seasonal locations roamed the vast expanses leaving little trace of his passing.

Modern man has permanentized village locations. Non-Native occupations have been associated with development of natural resources and this has left localized scars, as in mining. With the exception of these sites and the TAPS corridor, the area is basically as nature made it.

Over the entire route middle and background scenery is basically unimpacted by man's activity. Visual resources of the Wrangle Mountains are particularly outstanding. Vistas of the Alaska Range from Isabel Pass (50 road miles) and of the Chugach Range from Thompson Pass and environs are also outstanding.

Recreation Facilities--Existing--The existing facilities listed from north to south along the route are as follows:

1. Livengood Development Center. Southernmost development center for pipeline corridor visitors. Listed as existing due to nucleus of buildings remaining from mining era. Historic theme potential. Land title has not been researched.

2. Tolovana River Campground. Mile 57 Elliott Highway. Five camping units, well, vault toilets. An estimated 2,800 visitor days of use during 1974.

3. Tatalina River Campground. State of Alaska facility.

4. Fairbanks Urban Area. Numerous parks of various sizes and descriptions. Notably, Growden Memorial Park provides picnic units, flush toilets, city water and a group shelter.

Overnite camping facilities within the urban area apparently are not provided by any public agency. Privately operated pay camps (primarily for recreational vehicles or trailers) are available on a limited basis. This type of accommodation was previously more readily available but most spaces now utilized on a semi-permanent basis for pipeline construction workers.

5. Chena River Wayside. 27 acres, 62 camping units, 30 picnic units, water, pit toilets. Activities include: camping, picnicking, boating and canoeing.

6. Salcha River Picnic Wayside. 20 picnic units, pit toilets. Mile 323 Richardson Highway (MP 1479 Alcan).

7. Harding Lake Recreation Area. 89 camping units, 52 picnic units, pit toilet, water available. Mile 321 Richardson.

8. Donnelly Creek Wayside. 12 camping units, pit toilets. Mile 237 Richardson Highway.

9. Scenic Waysides. Numerous pulloff waysides are located between mile 240 and mile 198 on the Richardson. All have litter barrels; some have picnic tables. These are located to allow the traveler a safe point from which to view the north face of the Alaska Range.

10. Fielding Lake Wayside. Mile 200 Richardson Highway. A small 7-unit campground owned by the State of Alaska and administered, through agreement, by the BLM. Estimated visitor use was 3,000 visitor-days in 1974.

11. Paxon Lake Wayside. Mile 181 Richardson Highway. A small 3-unit campground with boat launch. Owned by the State of Alaska and administered, through agreement, by the BLM. Estimated visitor use was 9,000 visitor days in 1974. A departure point for the popular Gulkana River Canoe Trail utilized in 1974 by an estimated 100 parties constituting 2,400 visitor days.

12. Sourdough Campground. Mile 148 Richardson Highway. This 19-unit facility is heavily used as a recreation site for fishing, tourist overnight accommodations, and day use. It is State owned and BLM administered. Estimated visitor use in 1974 was 19,000 visitor days.

13. Dry Creek Wayside. 128 acres; Glenallen. Administered by the State of Alaska, Division of Parks - camping and fishing. Mile 118 Richardson Highway.

14. Tolsona Creek Wayside. Glenallen; administered by the State of Alaska, Division of Parks - Camping.

15. Squirrel Creek Wayside. Copper Center; administered by the State of Alaska, Division of Parks - camping and fishing. Mile 79 Richardson.

16. Worthington Glacier Wayside. 6 camping units, pit toilets. Mile 29 Richardson.

17. Blueberry Lake Wayside. 6 camping units, pit toilets. Mile 23 Richardson Highway.

Proposed--The proposals discussed below have been developed in a recent analysis by BLM and others of the trans-Alaska oil pipeline corridor. The final proposals will probably be similar in concept, although specific sites and recommendations may be adjusted. The listing is in north to south order along the route, as follows:

1. Sagwon Recreation Site. Proposed visitor facilities for campers and tourists traveling the north slope highway. Size and degree of development not identified.

2. Sagwon Bluff Raptor Protection Area. Proposed land use designation to protect falcon nesting area. Wildlife observation opportunity, but no direct contact allowed.

3. Galbraith Development Center. One of five centers proposed for commercial and visitor services between Fox and Prudhoe Bay. These are the only locations where fuel and supplies will be available. Galbraith will be a major Arctic Slope destination site for recreation.

4. Atigun Natural Area. Would provide for protection of unique scenic, wildlife, and ecological values of Atigun Canyon.

5. Chandalar Shelf. Proposed to be closed to or restricted for ORV use due to fragile ecological relationships and raptor nesting sites.

6. White Spruce Natural Area. Proposed protection for the northernmost stand of white spruce to provide scientific research opportunity.

7. Dietrich Development Center. One of five centers proposed for commercial and visitor services between Fox and Prudhoe Bay. This will be a major destination site for recreation and will provide access to the proposed Gates of the Arctic National Park.

8. Wiseman Historic District. National Register of Historic Places nomination is being prepared. No commercial development is anticipated although the location is suggested as a Gates of The Arctic portal by The National Park Service.

9. Middle Fork of the Koyokuk Scenic River. Proposed for study leading to nomination to National Wild and Scenic River System. Due to adjacent road, scenic classification probably governs.

10. Yukon Crossing Development Center. One of five centers proposed for commercial and visitor services between Fox and Prudhoe Bay. Will serve as orientation gateway to the north providing full interpretation and education facilities. Activity planning in progress.

11. Hess Creek Recreation Site. Proposed as an intermediate campground and recreation facility between development centers. Camping use has been noted at this location since the road north from Livengood was opened.

12. Kuck Lake Recreation Site. Site is approximately four miles from Elliott Highway on Manley Hot Springs Road. Extent of development not identified at this time. Within Fairbanks day-use zone.

13. West Fork Recreation Site. Together with existing Tolovana River and proposed Kuck Lake facilities, this site would serve through traffic visitors and Fairbanks day-use demand.

14. Tolovana Scenic River. River proposed for study leading to nomination to the National Wild and Scenic River System. Potential for canoe trail system.

15. Grapefruit Rocks Recreation Area. Site has moderate level present use for picnicking, rock climbing, and hiking. No facilities at present.

16. Wickersham Dome Recreation Lands. Would be managed to allow compatible uses for fire effect study, hunting, controlled ORV use. Grapefruit Rocks is within this overall proposal area.

17. Ober Creek ORV Area. Proposed development to focus on environmentally compatible ORV intensive use, primarily snow machine. Plans not developed at this time.

18. Lower Delta Recreation Access. Proposal contains provision for foot access to mountain areas east of Richardson Highway via Ruby, Bear and/or Darling Creeks. Also contemplates foot route across river to provide access to Black Rapids Glacier and the Alaska Range.

19. Delta Wild River. Proposal recognizes inherent qualification of upper Delta River for inclusion in the National Wild and Scenic Rivers system. Study, leading to nomination, scheduled for fiscal year 1975 under Bureau of Outdoor Recreation leadership.

20. Paxson Lake Recreation Area. This is a firm proposal, survey and design having been accomplished. Construction is anticipated with FY-76 appropriations although it could be put back to FY-77. Full development capacity includes access road, 40 camping units, plus 10 walk-in tent units, double boat ramp with parking, water system, vault toilets, and trailer dump station. Nature trails and other devices will be used to interpret the regional environment. Phase construction will include, as the first increment, 20 camping units, access road, boat launch with parking and water and sanitary systems. Expansion phases will be accomplished as demand warrants.

21. Gulkana Wild River. The proposal recognizes inherent qualifications of Gulkana River from Paxson Lake to the Copper River for inclusion in the National Wild and Scenic Rivers System. Study, leading to

nomination, scheduled for 1975 under Bureau of Outdoor Recreation leadership.

22. Trailheads Identified. Opportunities for conversion of oil pipeline gravel material pits to recreation purposes have been noted. These are at oil pipeline mileposts 616, 619, 624, 635, 641, and 643.

Air Quality

With four categoric exceptions air quality along the alternative route from Prudhoe Bay to Gravina Point is considered to be very high. The exceptions which are a combination of situations and location are:

1) The Prudhoe Bay oil and gas field (200 square miles) is a rapidly developing industrial complex supporting exploration, development and production of Alaska oil and gas.

2) The oil pipeline related camps and facilities all along the line;

3) The small towns and population enclaves along the highway; and

4) Fairbanks with its particular combination of air related circumstances. Fairbanks has had unique and acute air pollution problems created by both surface air inversions and ice fog conditions for some time.

Fairbanks is surrounded by low lying hills on the northwest, north and northeast. These hills range from approximately 500 to 1,000 feet above the city and form a natural boundary in these directions for a meteorological airshed which opens out into the very large and broad Tanana River Basin to the southwest, south and southeast.

Fairbanks experiences a climate-caused air inversion phenomenon causing carbon monoxide levels to exceed the State and National Ambient Air Quality Standard levels by as much as 200 percent.

For the months of January, February and December, 1972, the 9 ppm 8 hr. ambient air standard was exceeded on 73 percent of the days at the downtown post office measuring station. Eight hour average CO concentrations exceeded 9 ppm on 37 percent of the days, 15 ppm on 9 percent of the days, and 20 ppm on 3 percent of the days during 1972 (Gilmore and Hanna, 1974).

Surface inversions are present in Fairbanks in more than 60% of all nighttime atmospheric soundings. During December and January, when little diurnal fluctuation in the weather takes place, surface inversions are present at more than 80% of both day and night soundings. The winter inversions are unusual because they: (1) are among the strongest in the world, gradients of 20-30° C/-100m are not uncommon; (2) persist for prolonged periods, a full week is not unusual, and durations in excess of 240 consecutive hours have been recorded; (3) begin at the snow surface and extend upward for only 50-89m; (4) are sharply defined at the top by an abrupt order of magnitude decrease in temperature gradient; and (5) virtually decouple the dense surface air layer from the overlying air. During stable winter inversion conditions, the cold surface layer air stagnates and remains calm with winds less than 2m/sec, even though winds only 500 m aloft may exceed 15 m/sec. These inversions cause Fairbanks to have a severely restricted dilution volume, and thus a very high air pollution potential.

The interior of Alaska is subjected to numerous and persistent high pressure atmospheric systems, during which time calm weather conditions often occur. (Unpublished data, EPA).

Environmental Noise

This alternate gas transmission system would be built in an already designated and used transportation corridor for most of its length. For about 767 miles it will be in close proximity to the Prudhoe Bay oil and gas industrial development, the Trans-Alaska Oil pipeline with all of its ancillary facilities, a major State highway, and many small towns. Each of these things will constitute a source of noise. This alternative would add a significant amount of noise to the area during construction and at the compressor-maintenance station sites and the LNG plant area during its operational phase.

The amount of noise that would be generated by this project cannot be defined at this time because basic information regarding kind, timing and loudness is lacking. Also muffling systems for generators and other machinery has not been identified.

For the southernmost 42 miles of its length the pipeline would pass through an area which is wilderness in character. The only man-made sounds impinging on this area are those made by aircraft, boats, and an occasional hiker or hunter. This is the area in which the LNG plant and shipping area, a major industrial development, would be built.

LNG Transport (Marine Route)

This description of the environment along marine route is intended to encompass all of the possible marine transportation routes. The area can be described as one ecosystem, the Subarctic Pacific Region. This region by definition is the North Pacific Ocean lying north of 40° latitude and the Bering, Okhotsk and Japan Seas. Refer to Figure 8.2.1.-19 for geography locations. The waters off the Southern California Coast are not discussed in detail under this section; they are treated in greater detail relative to the receiving terminal and its operation (see section: The Terminal at Point Conception and the Pipelines to connect into Existing Distribution Systems).

The following description of the marine environmental setting is general and covers the routes between potential ports on the Alaskan Coast and on the Pacific Coast of the continental United States. Three aspects are considered, these are:

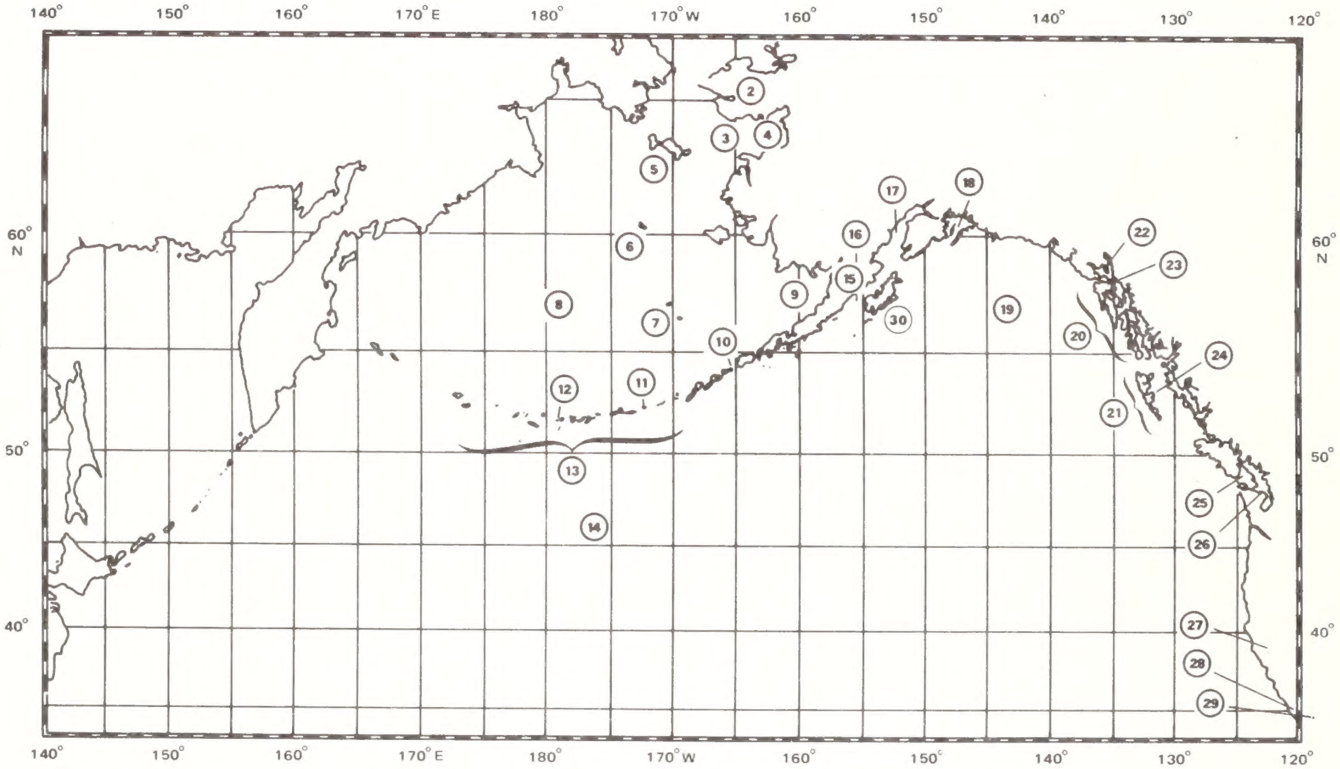
(1) natural physical systems

(2) biological systems, and

(3) the existing superimposed patterns of utilization of the living resources of the sea encountered along the route.

Climate and Weather

The general circulation in the northeastern Pacific Ocean (including the Bering Sea) is controlled largely by two major pressure centers. The Aleutian Low (Figure 8.2.1.-20) exists from September to June and represents the movement of extratropical cyclones across the northern Pacific. In the



① BERING STRAIT
② SEWARD PENINSULA
③ GOLOVNIN BAY
④ NORTON SOUND
⑤ ST. LAWRENCE ISLAND
⑥ ST. MATTHEW ISLAND
⑦ PRIBILOF ISLANDS
⑧ BERING SEA
⑨ BRISTOL BAY
⑩ UNIMAK PASS
⑪ AMUKTA PASS
⑫ AMCHITKA PASS
⑬ ALEUTIAN ISLANDS
⑭ NORTH PACIFIC OCEAN
⑮ ALASKA PENINSULA
⑯ SHELIKOF STRAIT
⑰ COOK INLET
⑱ PRINCE WILLIAM SOUND
⑲ GULF OF ALASKA
⑳ ALEXANDER ARCHEPELAGO
㉑ QUEEN CHARLOTTE ISLANDS
㉒ HAINES
㉓ LYNN CANAL
㉔ HECATE STRAIT
㉕ STRAIT OF SAN JUAN DE FUCA
㉖ PUGET SOUND
㉗ SAN FRANCISCO BAY
㉘ POINT CONCEPTION
㉙ LOS ANGELES
㉚ KODIAK ISLAND

Figure 8.2.1-19 Geographic locations

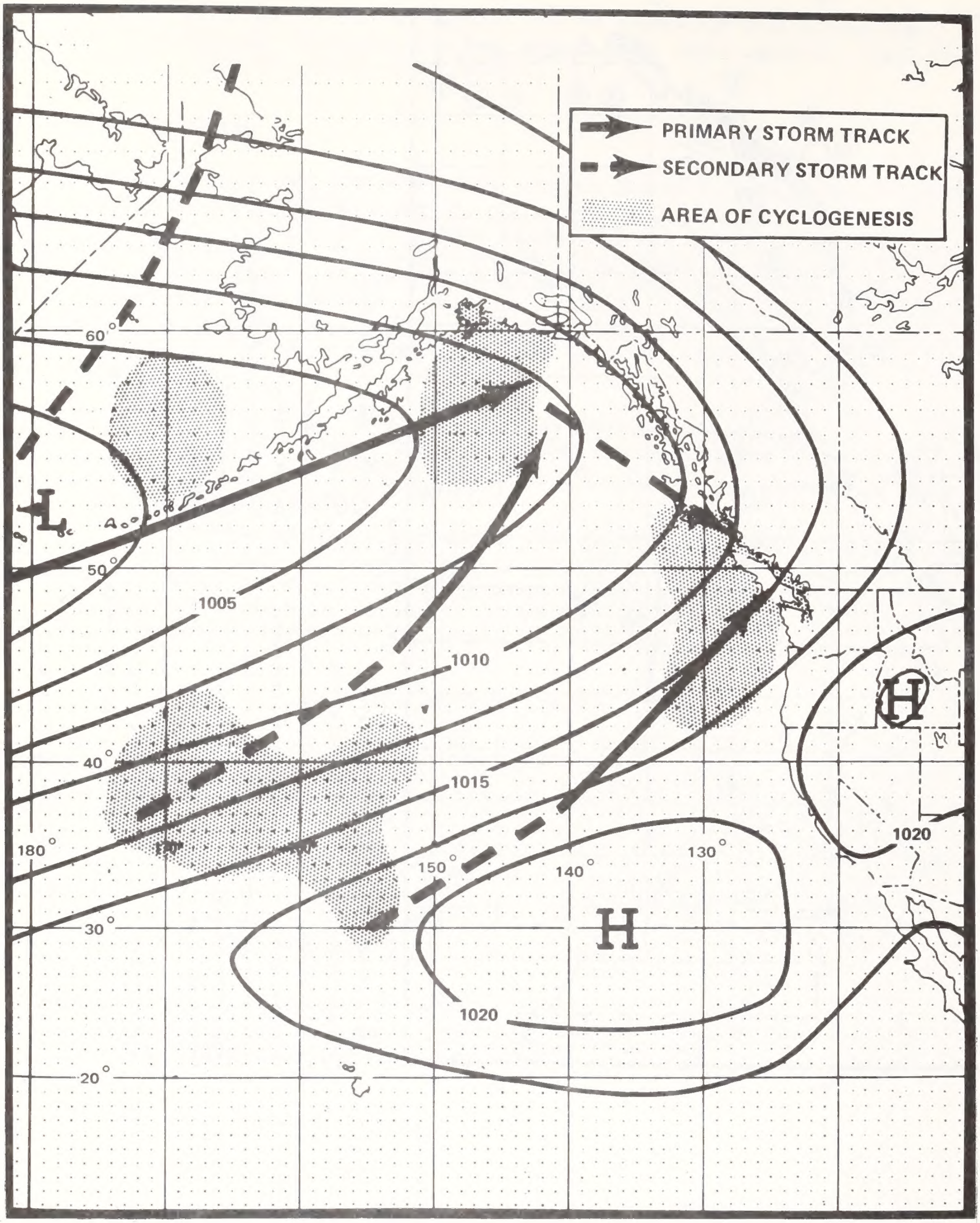


Figure 8.2.1-20 Mean monthly pressure and storm tracks - January

winter it dominates the northeastern Pacific north of 40°N. The North Pacific Subtropical High (Figure 8.2.1.-21) lies southeast of the Aleutian Low and is present throughout the year. It weakens and migrates southeastward in the winter. The Aleutian Low at maximum winter development is centered southeast of Kamchatka. The North Pacific Subtropical High is a high pressure ridge extending 1,000 miles southeast from California (USDOI, 1972).

In the winter the primary storm tracks enter the Gulf of Alaska from the west-southwest and southwest (Figure 8.2.1.-20). In the summer activity decreases with only one primary track reaching the Gulf (Figure 8.2.1.-21). During the cool months the Gulf has the highest frequency of extratropical cyclones in the Northern Hemisphere. These storms form on fronts and derive their energy from contrasting air masses. It is not unusual for the more severe to have winds of hurricane force (more than 65 knots). Eastern North Pacific tropical cyclones seldom affect waters north of 30°N. Fall and winter prevailing winds north of 40°N are westerly to southwesterly over the central section, changing to southerly near British Columbia and easterly off the Alaska coast.

Bad weather is the rule in the Bering Sea. There are frequent winds. Most of these fall between 6 and 8 on the Beaufort Scale (22-44 knots). Higher winds occur periodically. At St. Paul Island the average wind speed is 16 knots with an average yearly maximum of 49 knots. Winds of 99 knots were recorded in 1932. In late spring and summer the wind is usually accompanied by fog and rain. Gales, winds 28 knots and up, are most common in the fall. Along the Aleutian Islands, high winds and violent storms are common at all seasons of the year.

Average wind speeds are highest in the North Central Pacific Ocean area with a mean of 26 knots (December) and decrease slightly toward the Gulf of Alaska to a mean of 21 knots (December) and with decreasing latitude to 9-13 knots. Spring prevailing winds (up to 20 knots) are westerly to southwesterly over the open ocean, northwesterly south of Vancouver Island and east of 130°W, and southwesterly to southeasterly in the Gulf of Alaska. Summer winds are southwesterly in the Gulf of Alaska changing to northwesterly over more southerly waters. Mean winds speeds are 10-15 knots. Gale frequencies are highest in the North Central Pacific, diminish slightly toward the Gulf of Alaska and decrease significantly with latitude. Late fall and early winter are the times of maximum occurrence in northern waters and frequencies reach 26 percent at at least one station during December. In summer most of the northeastern Pacific has a gale frequency of less than 2 percent.

The distribution of high waves is roughly the same as that for gale force winds. Late fall and early winter are the seasons of maximum occurrence and the highest frequencies occur in the northern areas, particularly those areas away from coastal influences. At 50°N, 145°W, waves equal to or greater than 12 feet occur more than 20 percent of the time in October, November, January, and February, with the maximum of 36 percent in November. The frequency of high waves decreases slightly toward the Gulf of Alaska and south of 50°N there is a steady decrease of frequency of high waves with decrease in latitude. Some extreme wave heights have been reported in the northeastern Pacific. Recurrence values for high waves have been calculated for Ocean Station "P".

In the Bering Sea there is a substantial amount of time when visibility is restricted by fog and rain particularly in the late spring and summer. During the winter short day periods and blowing snow cut the amount of time with good visibility. In the vicinity of the Aleutian Islands a substantial amount of time with restricted visibility is the rule.

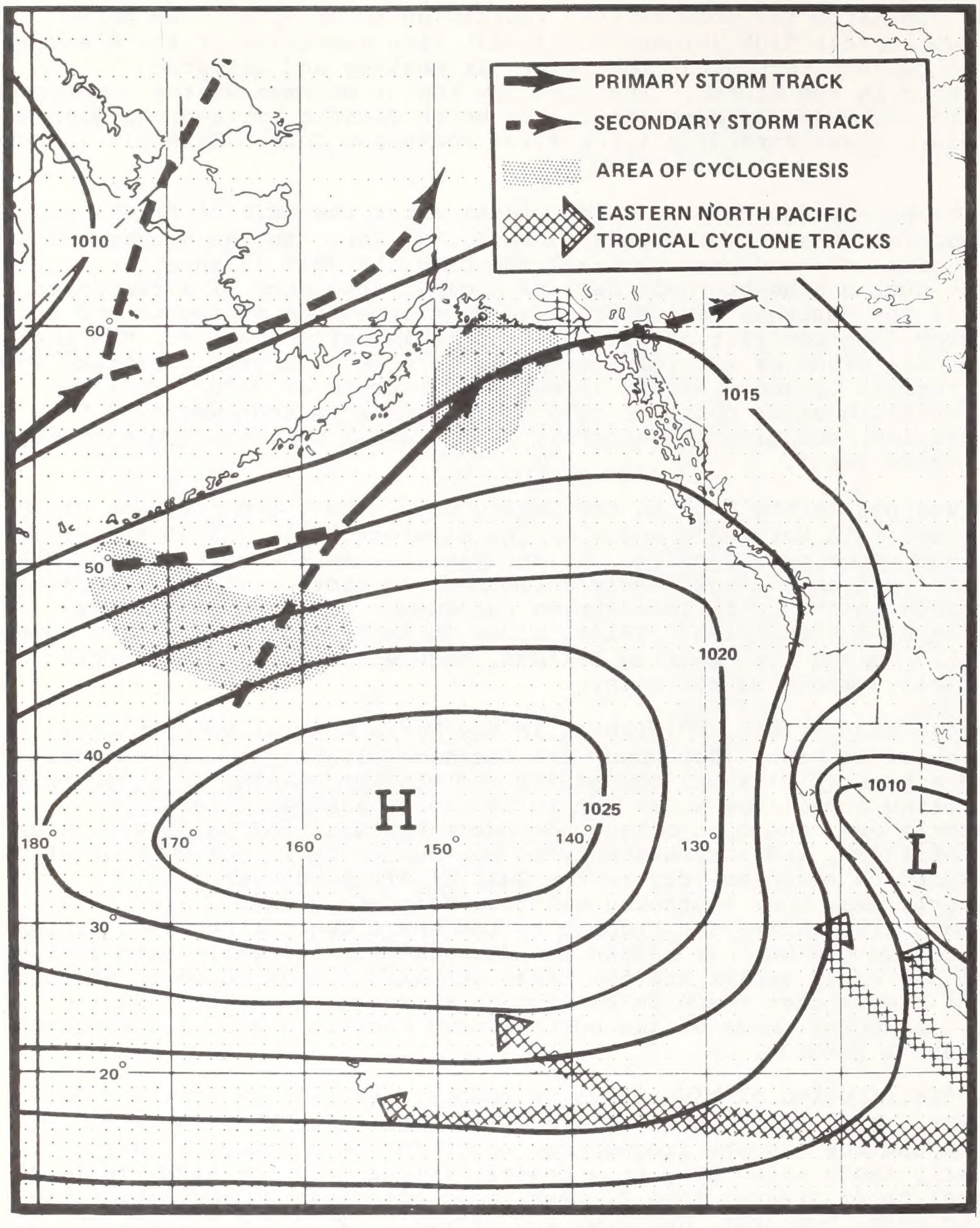


Figure 8.2.1-21 Mean monthly pressure and storm tracks - July

Mean recurrence interval (yr.)	Maximum significant wave height (ft.)	Extreme wave height (ft.)
2	36	64
10	49	89
25	58	104
50	65	118

The percentage frequency of restricted visibility (less than 2 nautical miles) reaches a maximum over most of the area in the summer months, although southern California areas peak in the fall or early winter. Coastal fog is so localized that it is not reflected in most ship area summaries, but must be found through individual coastal station analysis. In July most coastal areas north of 36°N have restricted visibility between 5 and 10 percent of the time and areas north of 34°N have less than 1/2 nautical mile visibility between 3 and 5 percent of the time. In the North Central Pacific Ocean area restricted visibility reaches 21 percent during July. South of 34°N visibility is generally good throughout the year. All areas north of 40°N have restricted visibility between 2 and 7 percent of the time in October, but the southern areas (between 34° -40°N) have 7 to 14 percent at that same time. In winter restricted visibility occurs 3 to 6 percent of the time in California areas and 6 to 10 percent of the time in most northern areas.

The northeastern Pacific Ocean is characterized by a wide range of temperatures with a strong north to south gradient. The warmest temperature and lowest seasonal ranges are observed in the southern California ocean areas, where temperatures seldom rise above 85°F. Freezing temperatures are almost never encountered south of 45°N, and near 50°N freezing temperatures are recorded 1 to 2 percent of the time in winter months. The Gulf of Alaska records a significant percentage of freezing temperatures from November through March or April and they are most common in January, reaching 23 percent in some areas. Surface air temperatures reach their peak during summer months. July averages range from 54°F in the north to 64°F in the South. Minimum temperatures are reached in January or February and are 15 percent to 20 percent below summer temperatures in the north. Arctic conditions prevail in the Bering Sea.

Percentage frequency of observations that include precipitation is at maximum for most northern areas in November and December and for southern areas in January. It is lowest over southern California marine areas and increases to a maximum in northeastern Gulf of Alaska. Winter frequencies are 15 to 30 percent north of 45°N, 8 to 15 percent between 35°N and 45°N, and less than 5 percent south of 35°N. Freezing precipitation occurs over waters north of Vancouver Island (51°N). By summer, coastal areas north of 45°N have precipitation 8 to 15 percent of the time. South of 45°N the frequency decreases rapidly. The northeast Pacific is, in general, a cloudy region. Most of the central ocean area has a mean cloud cover of 7 oktas (eights) throughout the year and the Gulf of Alaska averages about 6 oktas year round. The sky is overcast or obscured 40 to 60 percent of the time in northern areas and 20 to 60 percent in southern areas.

Local topographic and other effects modify these general northeastern Pacific features in the vicinity of the Gulf of Alaska, Puget Sound, San Francisco, and southern California. Some of the more pertinent of these modifications are summarized below.

Violent winds frequently occur on the leeward side of the coastal mountain range around the Gulf of Alaska. They occur suddenly and are extremely gusty. Sustained winds are also high and the predicted 50-year return values are around 100 knots. The same area is marked by restricted visibility 6 to 8 percent of the time in winter months and 6 to 12 percent in summer, with minimum of 4 to 5 percent in spring and 2 to 5 percent in fall.

Prince William Sound is poorly known climatologically. At the present time it can only be inferred that conditions are like those in the Gulf with some sheltering effects from the barrier islands.

A number of glaciers occur in the rugged mountainous terrain around Prince William Sound. The largest of these ice formations is the Columbia Glacier located at the head of Columbia Bay just west of the mouth of Valdez Arm which connects the Port of Valdez with the Sound.

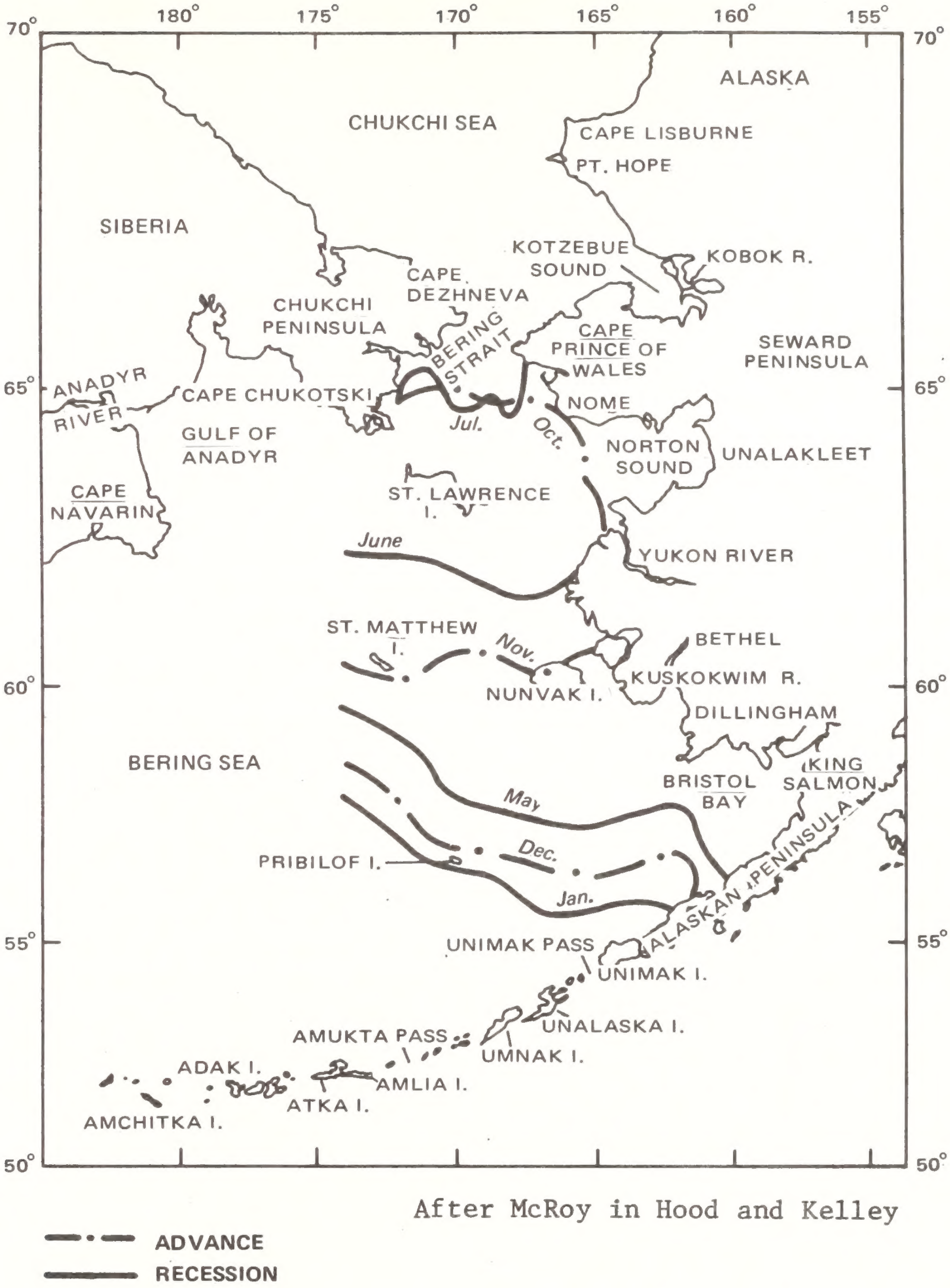
Columbia Glacier is a massive ice formation 425 square miles in area, several hundred feet thick and is four miles wide at its terminal end on Columbia Bay. This seaward end rests on shoal areas whereas the bulk of the glacier is believed to be located over a deep fiord with depths of at least two thousand feet.

Tidal glaciers, such as the Columbia, are an important source of icebergs. U.S. Geological Survey Scientists have recently labeled the Columbia Glacier as unstable. They warn that it could be on the verge of a drastic retreat that would discharge numerous icebergs into the shipping lanes of Prince William Sound. The Geological Survey has published an open file report 75-491 entitled, "Preliminary Hydrography, and Historical Terminal Changes of Columbia Glacier, Alaska." The report points out that once the front of the glacier retreats from its present resting place in the shoals into the deeper waters of the fiord the rate of break-up and retreat will increase drastically. As long as the front (terminal end) is over the deep water of the fiord, the glacier could discharge up to 50 cubic miles of ice into the sound over the next 30 to 50 years. Numerous icebergs would occur annually, some of immense size.

The general vicinity of the Strait of Juan de Fuca and Puget Sound is the site of fogs that form predictably under certain sets of winds and temperature conditions. These cause restricted visibilities during 9.2 percent of the time in July and 7 to 8 percent of the time in January and February in some offshore areas and more than 6 percent of the time from July through November in the area including Puget Sound. Local effects cause abrupt local variations in fog formation and duration. Fog signal operation records show the local variations in occurrence. Somewhat similar restricted visibility situation occur in the San Francisco Bay area, one of the differences being the greater persistence of the fogs there. Restricted visibility is also a characteristic of the Santa Barbara Channel of southern California.

Sea ice is a fact of life in the Bering Sea. This blanket of ice varies considerably in extent and nature from year to year. Ice conditions can not be predicted accurately. The ice thickness may be as great as 7 feet. Ice breakup begins early in June and by late June the drift ice at the face of the pack is usually somewhere north of Pt. Hope. The Bering Strait is generally closed again by late November. Figure 8.2.1.-22 shows the distribution of sea ice.

In upper Cook Inlet sea ice is also present during the winter. Unlike the Bering Sea this ice is generally broken and moving because of the extreme tidal range in the inlet. While tankers in Cook Inlet have to pass through brash and ice pans this ice should pose no real problems.



After McRoy in Hood and Kelley

Figure 8.2.1-22 Sea ice

Coastline

The Aleutian Islands - Commander Islands arc separates the Bering Sea from the North Pacific. These islands occupy a narrow, interrupted shelf rising abruptly out of the depths of the Aleutian Trench on the south and grading away more gradually into the relatively shallow Bering Sea to the north. The coastline of the Bering Sea tends to be relatively flat and monotonous, its morphology in keeping with the extensive shelf offshore. Several islands line the potential shipping lane. Eastward and southward from Unimak Pass to the Strait of Juan de Fuca the coastline is precipitous and embayed by complex fjord systems. The pattern is broken for a short distance in the northeastern Gulf of Alaska between Cape Suckling and Cross Sound where the St. Elias Mountains back a shoreline with long, regular beaches and few interruptions. Between the Strait of Juan de Fuca and Los Angeles the coast is generally of a rugged but relatively regular nature; a mixture of cliffs and headlands interspersed with beaches, terraces and dune fields.

The entire coastline from Unimak Island to the Strait of Juan de Fuca is fronted by islands, islets, stacks and rocks. These range in size from rocks that are little more than shoal areas to the massive islands of the Alexander Archipelago, Kodiak Island and Vancouver Island. Collectively they exert a considerable influence on the associated marine environment.

Between the Strait of Juan de Fuca and California's Channel Islands there are no large islands. There are many islets, rocks and stacks. These are more heavily concentrated on the northern half of this coast. They do not influence the coastal environment to the extent that the larger islands along the Alaska and British Columbia coasts do. There are a number of major embayments and straits between Bering strait and Los Angeles Harbor. The northern-most is Norton Sound which lies between the Seward Peninsula and the delta of the Yukon River. South of this sound lies Kuskowim Bay the seaward extension of the Kuskokwim River estuary. Bristol Bay, the major bay on the eastern shore of the Bering Sea, lies directly to the south between Cape Newenham and the Alaska Peninsula. Between the south coast of the Alaska Peninsula and the Kodiak-Afognak Archipelago lies Shelikof Strait the western approach to Cook Inlet. Cook Inlet is a long, relatively narrow northeasterly trending bay which almost separates the Kenai Peninsula from mainland Alaska to the north and west.

The Gulf of Alaska is a broad expanse of water which includes all of the northeastern corner of the North Pacific Ocean eastward of a line from the southernmost tip of Kodiak Island to the southern end of Dall Island on the north side of Dixon Entrance. At the northernmost extension of the Gulf of Alaska and almost cut off from the gulf by a series of islands is Prince William Sound a body of water with an areal extent of about 70 by 100 miles. The next waterways to the south are all part of the complex network of straits, sounds and channels of the interior of the Alexander Archipelago.

South of Alaska are many smaller but still significant water areas. The northernmost, Dixon Entrance, lies between the Alexander Archipelago and the Queen Charlotte Islands. It is the northern approach to Hecate Strait which lies between the Queen Charlottes and the coast of mainland British Columbia. South of the Queen Charlottes, Hecate Strait gives way to Queen Charlotte Sound. At the southern end of this sound the Strait of Georgia leads away to the southeast on the mainland side of Vancouver Island. These coastal waters along with the waterways of the Alexander Archipelago provide almost continuous sheltered passage from Haines, Alaska to Puget Sound and the Strait of Juan de Fuca. South of the Strait of Juan de Fuca, the estuary of the Columbia River and San Francisco Bay are the largest roadsteds encountered.

Bathymetry

Many areas along the potential LNG shipping lanes are inadequately surveyed and charted by modern standards.

The outstanding bathymetric feature of the Bering Sea, completely dominating the northeastern half, is the continental shelf. It bridges the bottom from Bristol Bay on the Alaska side to the Anadyr Gulf on the Siberian side.

Golovin Bay is too shallow for LNG carriers the size of those described above. Adequate water 11-15 fathoms deep can be found at either side of the entrance. A natural channel up to 15 miles wide leads from the entrance of Golovin Bay to the mouth of Norton Sound. There are some known obstructions but the general depth runs between 11 and 13 fathoms. From the mouth of Norton Sound south the water over the continental shelf gradually deepens from 13 fathoms to more than 70.

Carriers making for Unimak Pass are over the shelf until they pass out into the North Pacific. The routes through Amukta and Amchitka passes cross the continental slope about 60 miles south of St. Paul Island and are never in less than 100 fathoms from there to the west coast.

Unimak Pass is a narrow pass, 11 miles wide, between Unimak and Ugimak Islands. The water shoals to between 10 and 60 fathoms in the pass. Amukta Pass some distance west of Unimak Pass is a broad pass between Amukta and Seguam Islands with ample water over 100 fathoms deep. Still further west is another broad pass with water over 100 fathoms deep, Amchitka Pass. It lies between Amchitka and Amagat Islands.

South of these passes lies the extremely deep water over the abyssal plain. Tankers plying the sea lanes to the west coast would not cross the continental shelf again until they make the approach to their destination port.

At Nikishka water over 10 fathoms lies closer inshore than it does at any other point in Upper Cook Inlet. A narrow pocket of water from 17 to 22 fathoms deep lies directly on shore at East Foreland which could be provided with a dredged channel (hard to maintain) exit to the south where water shoals to 6.3 fathoms mean high water. South of the Forelands adequate water up to 50 fathoms exists to the mouth of the inlet.

Stevenson Entrance, the standard shipping passage out of Cook Inlet, lies between the Barren Islands and Shuyak Island. It is about 10 miles across with most of its water over 50 fathoms. South from there to the west coast there is deep water the rest of the way.

Seal Rocks form a local barrier to a straight clean passage into the Gulf of Alaska from Prince William Sound. The route between those rocks and Hinchinbrook Island passes seven miles northeast of Wessels Reef, which is two miles long by one mile wide. The route then makes a clear deep passage into the Gulf. A gradual rise beyond Hinchinbrook Entrance and prior to the clear-deep passage into the Gulf reaches shoalest depths of 32 fathoms. East of Middleton Island, the deeper water of the Gulf of Alaska is reached and the route turns south-eastward toward Point Conception 1,800 miles away (DOI, 1972).

Numerous seamounts are present along the route between 54°N and 40°N, but only two, Bowie at 15 fathoms and Cobb at 18 fathoms are any conceivable hazard to surface navigation. Between 40°N and 34°N latitude at southern

California there are major spurs, ridges, and escarpments at greater than 1,500 fathoms.

The Strait of Juan de Fuca and Puget Sound are restricted waters that are approached past La Perouse Bank (23 fathoms minimum), Swiftsure Bank (19 fathoms minimum), and rocks extending two miles north of Cape Flattery. The western 50-mile length of the Strait is deep and generally clear of obstructions. However, the bottom for the eastern 30 miles is extremely irregular with numerous isolated, submerged shoal banks which rise from general depths of 60-80 fathoms to various lesser depths. At its southeastern corner the Strait opens into Admiralty Inlet and Puget Sound with a maze of islands and peninsulas and shoalest depths of 20 fathoms to Seattle. At its northeastern corner the Strait connects via Rosario and Haro Straits with the Strait of Georgia. Rosario Strait has an uneven bottom with general depths of 28-40 fathoms and scattered pinnacle rocks. Haro Strait is similar. The Strait of Georgia is a relatively smoother and deeper basin.

San Francisco Bay and adjoining bays are restricted waters that are approached through the Gulf of Farallons and the narrow Golden Gate. A submerged bar with shoalest depths of 4 fathoms lies in the Gulf off the Golden Gate and deep draft passage is made through an improved channel 2-3/4 miles long and 2,000 feet wide with a project depth of 55 feet (9.16 fathoms). San Francisco Bay proper is characterized by broad shallow areas of 12 feet or less depth along almost all shores, natural and man-made islands and peninsulas, submerged pinnacle rocks, and submerged shoal banks. In general, controlling depths of the deep channels are less than 36 feet.

South of 34°N latitude to the boundary with Mexico the bottom topography is a complex of basins, ridges, and banks oriented generally parallel to the coastline. In a NW-SE direction off-lying islands represent culminations of some of the ridges. Elsewhere, depths of greater than 100 fathoms are generally present.

Point Conception lies on the north side of the seaward end of the Santa Barbara Channel. The first landfall on the port leg is Point Arguello. From there to Point Conception, 12 miles away, the coast breaks away gently to the southwest. There is adequate water close in to shore.

Marine Geology

Although there is only limited geological knowledge of some of the marine areas, enough is known to establish the general relations between the onshore and offshore geology.

The Bering Sea continental shelf is one of the most extensive adjoining any continent. It appears to be a submerged portion of the large continental plate that includes North America and northeastern Siberia which probably submerged in the late Tertiary. The shelf consists of a structural sequence of eroded and folded rocks of three distinct tectonic origins beneath an acoustical basement, a layer of Tertiary sediments known as the Main Layered Sequence, and a layer of Quaternary age sediments which range in depth from a few to about 100 meters in depth.

The abyssal basin in the southwestern half of the Bering Sea is probably an embayment of the Pacific Ocean which was isolated by the uplift of the Aleutian Ridge. This basin is divided into three smaller basins--Aleutian, Bower and Commander Basins--by the Shirshov Ridge and Bowers Bank. In the Southeast corner of the Bering Sea is a large area of intermediate depth, the Unimak Plateau, which may be a foundered piece of continental plate. The deep basin area is mantled with 1-10 kilometers of Quaternary sediments (Scholl et al., in manuscript).

The Aleutian Ridge is topped by the Aleutian Island Arc and is thought to have originated from the Pacific plate underthrusting the North American-Eurasian plate (Scholl et al., in manuscript). The Aleutian Trench on its southern face is caused by the subduction of the Pacific plate. The Aleutian Range lying to the northwest of the Gulf of Alaska is thought to have a similar origin.

The Chugach and St. Elias Mountains rim the Gulf of Alaska and consist dominantly of sedimentary and some volcanic rocks of Mesozoic age. These rocks are locally metamorphosed and cut by granitic masses of Tertiary age. Most of the offshore and some onshore areas are underlain by marine sedimentary rocks of Tertiary and Quaternary age; glacial deposits of various kinds form thick sequences overlying the Mesozoic basement rocks. In the inner parts of the fiords, the submarine deposits are thin and relatively recent in age. Structures in the Tertiary rocks generally parallel the coastline. The major faults of the region, the Chugach and the Fairweather, intersect and offset all of the rock units (USDOI, 1972).

The Alaska continental shelf narrows to the southeast and the marine Tertiary rocks are absent in southeastern Alaska, where Mesozoic rocks like those further northwest occur in association with crystalline rock complexes, diverse sedimentary and volcanic rocks of Paleozoic, Mesozoic, and Tertiary age, and minor Holocene volcanic rocks. On the British Columbia offshore islands, Tertiary sedimentary and volcanic strata overlie Mesozoic sedimentary, volcanic and plutonic rocks. Some distinct sedimentary basins of Tertiary age occur offshore. The continental shelf is narrow and appears to be bounded by the important Queen Charlotte Islands fault.

The geology of the Strait of Juan de Fuca-Puget Sound area is dominated by thick sequences of Tertiary volcanic and sedimentary rocks, Puget Sound, itself, is underlain mostly by thick Pleistocene glacial materials that rest on Tertiary rocks. Tertiary volcanic and sedimentary rocks underlie much of the onshore and offshore region between the Strait of Juan de Fuca and southern Oregon; glaciomarine deposits are locally important. The continental shelf is about 20 miles wide and is crossed by large submarine canyons through which fan materials have been transported seaward.

In southern Oregon and northern California, Holocene marine deposits overlie Tertiary sedimentary and volcanic strata and Mesozoic volcanic, metamorphic and ultramafic rocks. Tertiary basins occur both onshore and on the continental shelf, which is about 10 miles wide at Cape Mendocino. Folds and faults are common both on- and offshore. The same types of rocks are present along the coast of central California but the continental shelf broadens to 30 miles and large scale faulting, including movements on the San Andreas fault, has juxtaposed different blocks of Mesozoic and Tertiary rocks. Quaternary sediments crop out on prominent terraces both on- and offshore. South and east of Point Conception, the structural grain of the onshore and offshore rocks changes from north-northwest to east-west and Mesozoic sedimentary, volcanic and metamorphic rocks are overlain by Teritary sedimentary and volcanic rocks and Quaternary marine terrace deposits. The structural grain reverts to north-northwest near Los Angeles, where a basin with a thick sequence of Cenozoic and Mesozoic sedimentary and volcanic rocks and a complex fault history occurs on a basement of Mesozoic sedimentary and volcanic rocks and a complex fault history occurs on a basement of Mesozoic metamorphic and other rocks.

The whole coast between Western Alaska and southern California is seismically active, although some portions are clearly more active than others. The more active portions are Prince William Sound, the Gulf of Alaska, and California. Epicenters of some of the largest historic earthquakes occurred in these areas and the magnitude and frequency or future seismic events are qualitatively predicted to be high.

Petroleum resources occur at several localities along the coast but significant production has come only from California. Natural oil seeps in the Gulf of Alaska marine Tertiary basin led to early drilling and minor production; interest in the offshore potential remains high. A lease sale currently appears imminent in the Gulf of Alaska. Many wells have been drilled in the Tertiary rocks of the Queen Charlotte-Vancouver Islands and in the Strait of Juan de Fuca-Puget Sound areas, but no production has resulted. Tertiary strata along the Washington and northern Oregon coasts have been tested, but the one successful well had only limited production. The onshore parts of the Santa Cruz and Santa Maria basins of central California have produced some petroleum but the potential offshore is untested as yet. Significant on- and offshore production has been obtained from Tertiary strata in the Santa Barbara area. The most significant petroleum production in the area has been in the Los Angeles basin where both onshore and offshore resources are being exploited.

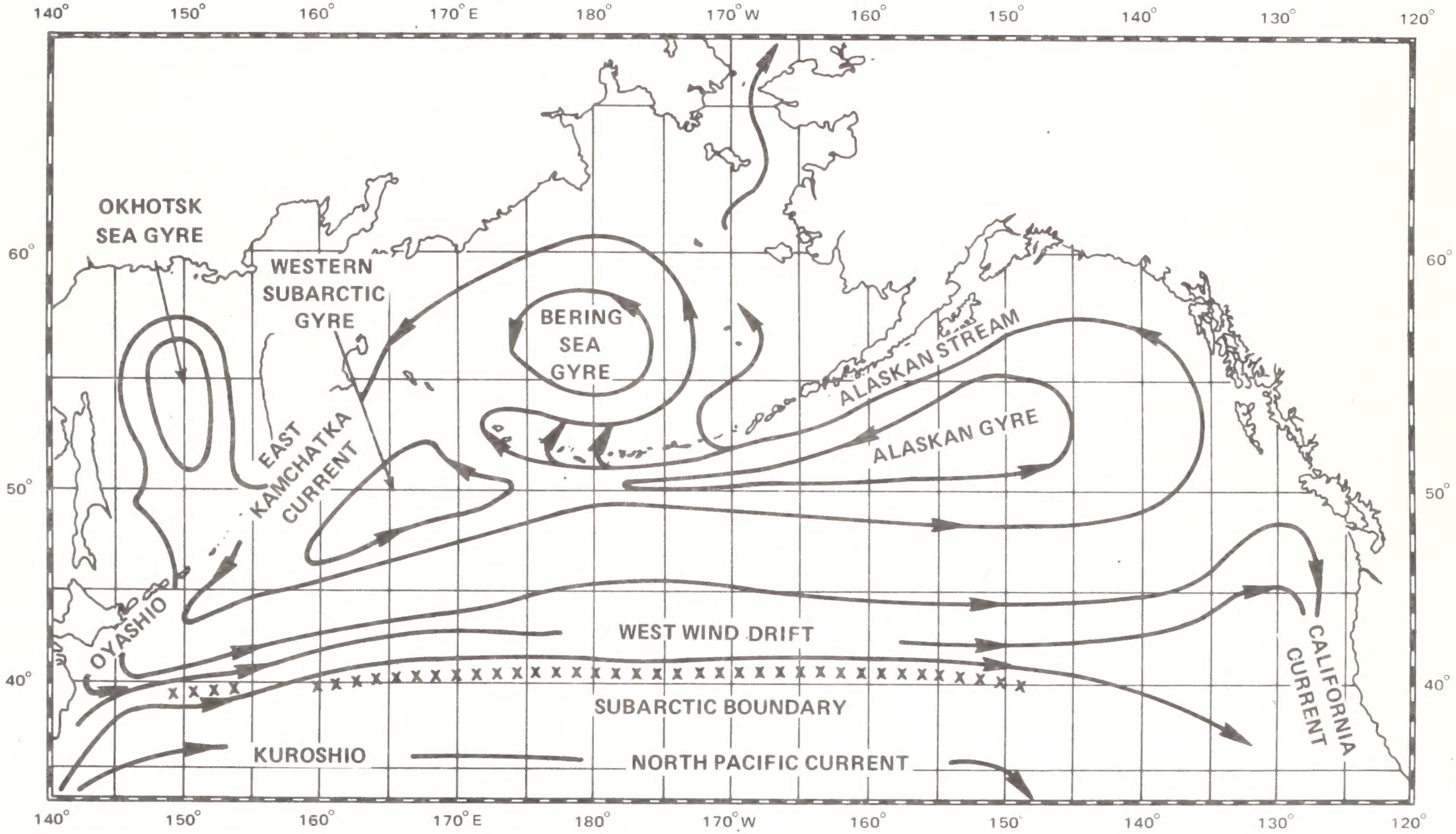
The Water Column

Circulation--The significant features of the Subarctic circulation as described by Dodimead, Favorite and Hirano (1963) are: (1) A major gyre with four subsidiary gyres; Bering Sea, Western Subartic, Okhotsk Sea and Alaskan (Figure 8.2.1-21); (2) The confluence of the Oyashio and Kuroshio currents; (3) The division of the waters off the North American Coast; and (4) The strong westward flowing Alaskan Stream immediately south of the Aleutian Islands.

The overall result is an almost closed system of surface circulation which takes the form of a major gyre with several superimposed subsidiary gyres. Some water escapes the system through the Bering Strait but the significant loss to the system is through the California Current. The roundtrip time for water within the system is from 4 to 6 years.

Two western Pacific currents influence the current systems in the area which would be traversed by the potential LNG tanker routes. These are the warm, saline Kuroshio and colder and less saline Oyashio currents. The Kuroshio moves northward along the southern Japanese Islands to about 36°N where it is split. The main stem moves eastward across the Pacific to the south of the Subarctic Pacific Region as the North Pacific Current. The remainder of this current continues northward to about 40°N where it collides with the south flowing Oyashio Current. Part of the Oyashio Current is deflected northeastward toward the Aleutian Islands. The resulting Subarctic Current moves eastward at about 2 nautical miles per day. It eventually reaches the Gulf of Alaska looping around the Alaskan Gyre and returning as the strong (8-10 nautical miles per day) westward flowing Alaska Stream (Figure 8.2.1.-23).

The remaining waters from the two western Pacific currents are extensively mixed vertically and horizontally. The result is a complex and variable, mixed water which moves eastward at 2-4 nautical miles per day as the West Wind Drift. This drift angles northeasterly to about latitude 45°N and longitude 180°. From there it moves directly eastward to approximately 300 miles from the Washington-Oregon coast where it divides. Some of the flow turns north into the Gulf of Alaska, part of it moves southward in the



AFTER DODIMEAD, FAVORITE AND HIRANO, 1963

Figure 8.2.1-23 Surface circulation in the subarctic Pacific region

California Current and a small remnant intrudes into coastal waters off Vancouver Island eventually moving southward as a coastal current. The physical properties, structure and dynamics of these coastal waters are significantly influenced by seasonal variations in fresh water intrusion, winds, tides, advection, and temperatures.

The California Current moves water southward from the West Wind Drift and the North Pacific Current, mostly within 1,000 km of the California Coast. This water joins the North Equatorial Current and moves westward toward Hawaii. A counter current, the Davidson Current, develops inshore from the California Current during the fall and winter. From October to May, the Davidson Current transports water as far north as 50°N where it merges with the Alaska Current.

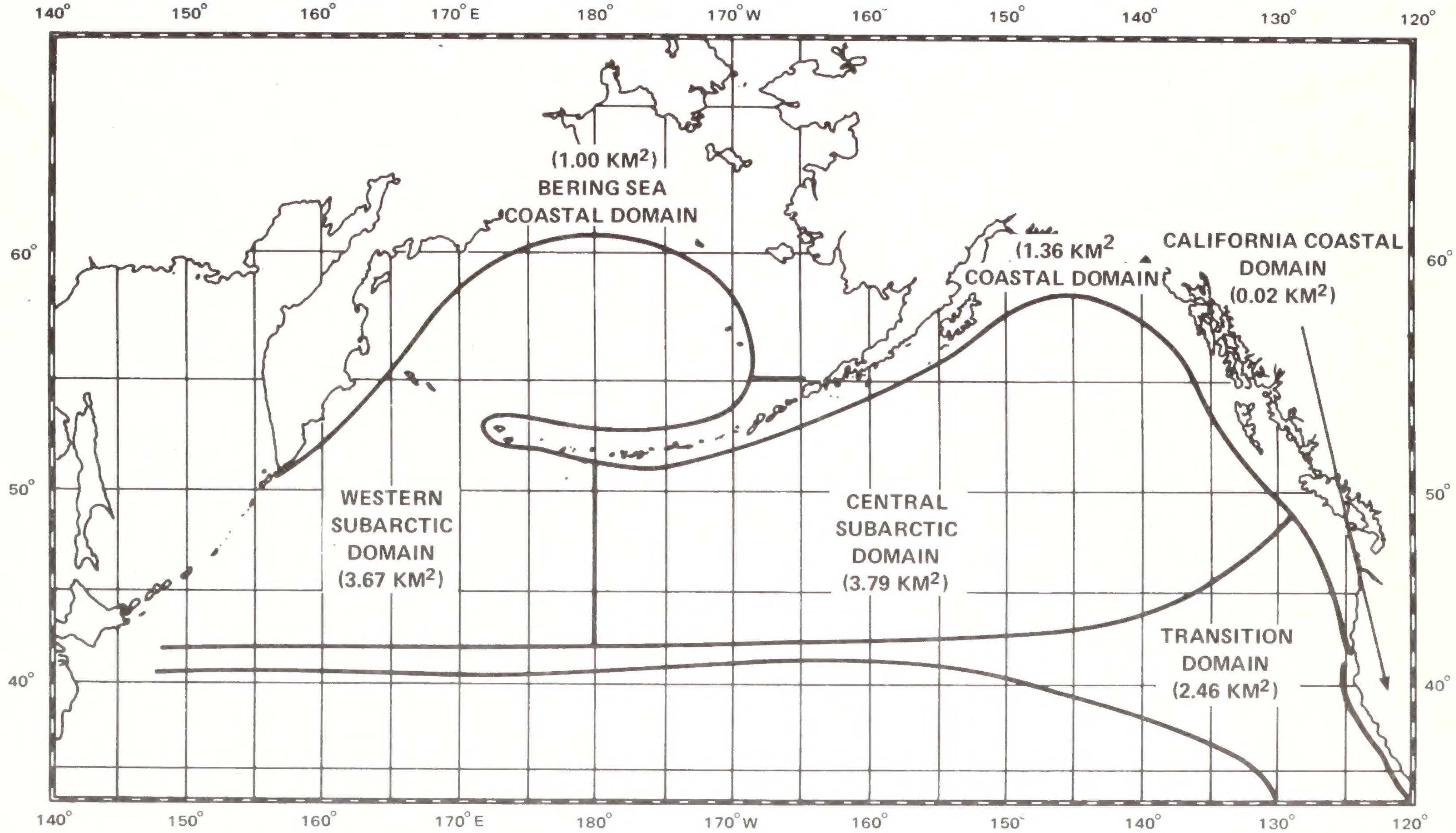
Water from the Alaska Stream enters the Bering Sea through several passes through the Aleutian Chain. The bulk of it turns northwest of Attu Island. From there it flows back eastward along the north side of the Aleutians mixing again with the surface waters which intruded through the passes. The main circulation is cyclonic with some of the water passing out of the Bering Sea as the East Kamchatka Current and the rest being trapped in the Bering Sea Gyre. Water which escapes the cyclonic circulation moves northward over the continental shelf and escapes the system through the Bering Strait.

Chemistry--The salinity structure of the water at Ocean Station PAPA is typical of that encountered in the Subarctic Pacific Region. Permanent features are an upper zone from the surface to about 100 meters, a halocline from about 100-200 meters depth with a 1% salinity increase throughout its depth and a lower zone which lies below the isohaline surface of salinity = 33.8% (Dodimead, et al, 1963).

Chemically, the North Pacific Ocean can be divided into three basic surface water types: high salinity water (more than 33%), lower salinity (less then 33%) mixed coastal estuarine water, and nutrient laden waters brought from depths by upwelling. The West Wind Drift supplies most of the surface waters along the Alaska coast and the chemical preconditions of Alaska waters are probably derived from this source. Regional wind, climate and local summer conditions also determine the nutrient and oxygen levels. Nutrient levels of the Northeast Pacific Ocean are generally high as a result of vertical mixing caused by storms. This is partially modified during summer months by development of a surficial low salinity layer. Dissolved oxygen concentrations in the deep waters are relatively low as a result of the sluggish circulation of the deep Pacific. Surface waters are well oxygenated because of mixing at the surface.

The Biological Component

Primary Production--The primary productivity of phytoplankton in the Subarctic Pacific Region has recently been estimated by Sanger (1972a) as being 1.28 x 10 tons of carbon per year. Primary productivity can be defined as the rate at which plants produce organic material from inorganic material through photosynthesis. Sanger has derived five zones in which primary productivity ranges from 48-160 grams of carbon per square meter of surface per year, (gC/m²/yr) Figure 8.2.1.-24. Sanger has addressed himself to gross estimates for a very large area. Locally primary production can be much higher. Larrance (1971) reports primary production of 332 g. C/m²/yr in Adak Bay.



AFTER SANGER

Figure 8.2.1-24 Surface domains in the subarctic Pacific region

Motoda and Minoda (1974) have reported surface primary production for the Bering Sea in summer ranging from 5 mgC/m²/hr east of Bowers Bank to less than 1 mgC/m²/hr on the northern shelf and the western Bering Sea Gyre. The density of the standing crop of diatoms on the surface ranged from 1 x 10 - 10 cells/m.

Local variations in primary productivity can be predicted. Places where elevated production can be anticipated are, for example: (1) bays and estuaries where the photic zone (the portion of the water column where enough light exists for photosynthesis) reaches the bottom; (2) in areas where discharge plumes from river supply extra nutrients; and (3) in areas where upwelling water or turbulent mixing brings up nutrients from below the photic zone.

The Adak Bay example is illustrative of the first type of area. The discharge plume of the Copper River elevates nutrient levels in the northern Gulf of Alaska. The violent weather in the Gulf of Alaska results in a high degree of turbulent mixing. The Alaska Gyre (Figure 8.2.1.-23) is an additional source of upwelling in the Gulf of Alaska. Cyclonic gyres are depressed in the center causing upwelling of water from underneath to correct the resulting pressure imbalance. Areas with depressed productivity can also be predicted. The high degree of turbidity in Upper Cook Inlet causes lower productivity through its reduction of the photic zone.

Epibenthic phytoplankton provides an unknown but presumably significant increment to overall primary productivity. In Arctic areas such as the Bering Sea, diatom blooms under the sea ice in late winter also contribute to total productivity. Primary production and phytoplankton standing stocks in the water below the ice are low during the winter. In marked contrast to this is the intense development of microalgae on the undersurface of the sea ice which constitute a major standing stock of primary producers from March to breakup in May (McRoy and Goering, 1974). The ice algae community occupies the lower 5 cm of ice. The estimated productivity of the ice community for the March-April period ranges from 44.4 to 95.4 mgC/m³/day on a volume basis and 2.2 to 4.8 mgC/m²/day on an areal basis. In the water column at the same time productivity under the ice was 15 to 20 mgC/m²/day while at the ice front it was 89.28 mgC/m²/day.

Eelgrass, Zostera marina, is the most important marine seed plant. It is locally abundant in protected bays, inlets and lagoons with muddy or sandy bottoms. It occurs from about 2 feet above to 20 feet below low tide level. McRoy (1970) has reported standing crops (plant biomass) of eelgrass for several Alaskan localities. Some of these are, as follows: Safety Lagoon (Norton Sound) and Sawmill Bay (Prince William Sound), 415 grams dry weight per square meter; Izembek Lagoon, 1510; and Craig (Prince of Wales Island), 113.

The eelgrass beds in the many shallow lagoons bordering the Bering Sea have a level of productivity which far exceeds equivalent areas of the adjacent ocean. In Izembek Lagoon, the eelgrass beds annually produce 166,000 metric tons of particulate carbon, 7,400 metric tons of nitrogen, 1,660 metric tons of phosphorus, 386 metric tons of silica and 3.45 metric tons of copper (Barsdate, Nebert and McRoy, 1974).

Keller and Harris, 1966, have reported on biomass (standing crop) in relation to water depth for eelgrass in Humbolt Bay, California. Their data are summarized in the table on page 319. Depth is relative to mean lower low tide.

The macroalgae dominate the vegetation in most intertidal and subtidal areas. They are a diverse group. In British Columbia waters there are about 500 species. The depth distribution of the algae is variable. In the

Relative Depth	Biomass
+1.0	3.9 g. wt./ft^2 (39 g. wt./m^2)
+0.5	8.1 g. wt./ft^2 (87 g. wt./m^2)
0.0	12.0 g. wt./ft^2 (129 g. wt./m^2)
-0.5	17.8 g. wt./ft^2 (191 g. wt./m^2)
-1.0	31.7 g. wt./ft^2 (341 g. wt./m^2)
-1.5	31.1 g. wt./ft^2 (334 g. wt./m^2)

turbid North Pacific waters off British Columbia, they are rarely found below 100 feet. Their biomass is large. MacFarland and Frescott (1959) reported wet standing crops for a *Macrocystis pyrifera* community in Paradise Cove, California ranging from 4.35 to 5.78 kg/m^3. Approximately 50% of this biomass was found between the surface and 1.5 meters below it. A 1911 survey estimated that there were 389 square miles of Kelp beds containing 59 million tons wet weight of kelp along the Pacific Coast of North America.

The most conspicuous because of their size and long-term annual to perennial persistence are the giant kelps. Druehl (1970) has taken advantage of this fact, defining three distinct floras for the 7,880 km coastline from Attu Island, Alaska to Santa Margarita Island, Baja California based on the distribution of the Laminariales. There are 40 laminarians belonging to 19 genera and four families along this coast. His southern zone flora fronts the coast from Santa Margarita Island to the Strait of Juan de Fuca. This segment has the greatest species diversity in the families Lessoniaceae and Alariaceae of any of the segments. There is, however, only one *Alaria* in the zone. There are 10 species of Laminarcaceae in 5 genera, 9 species of Lessoniaceae in 7 genera and 7 species of Alariaceae in 4 genera. The northern zone extending from Hope Island, British Columbia to Yakutat, Alaska is typified by the large number of species of Laminariaceae and *Alaria*. The zone contains 13 species of Laminariaceae in 6 genera, 10 species of Alariaceae in 4 genera, 3 species of Lessoniaceae in 3 genera and 1 species of Chordaceae. All 7 *Alaria* known on the Pacific coast are found in this segment. The western zone flora found from Kodiak Island to Attu shows a very low species diversity, containing 11 species of Laminariaceae in 6 genera, 3 species of *Alaria* and 1 species of Chordaceae.

The segments are separated by transition zones. The zone between the southern and northern segments is essentially found on the coast of Vancouver Island. It contains 28 species of Laminarians. The other transition zone is located on the Gulf of Alaska Coast between Yakutat and Kodiak Island. Twenty-two species of laminarians are found there, 15 occur also in the segments on either side.

Something like 90% of the primary productivity of the sea is attributed to the phytoplankton. The rest of the contribution is shared by other microalgae, the macroalgae and flowering plants. There has been less work done to establish the relative input of these components. There is indirect evidence to suggest the role of the macroalgae. Investigations of oil spills have given evidence of dramatic expansion of kelp beds for a time after a spill. Marine molluscs are usually greatly reduced in number by these same spills. The inference is that the algae thrive in the absence of molluscs. This indicates a high level of utilization of algae by grazing molluscs. Valentine's (1966) study of mollusc distribution on the northeast Pacific shelf provides another piece of indirect evidence of a tie between molluscs and algae. There are many parallels between mollusc distribution and Druehl's interpretation of the distribution of the Laminariales, presumably because of a direct tie between grazers and their preferred forage.

An additional locus of primary production of the marine environment is the intertidal salt marsh. There are numerous salt marshes along the Pacific Coast. They are usually found at the heads of bays and on the deltas of large rivers. Most of the southern ones have been much reduced by man's activities.

Hanson (1951) has reported on some of the plant communities of intertidal marshes on Cook Inlet. The vegetation is zonal with respect to the degree of inundation. *Puccinellia phryganodes* is the dominant plant of Zone 1 which lies at the lowest level. This plant roots rapidly and runners extensively forming dense mats which are tolerant of tidal and wave disturbance. *Salicornia herbacea*, *Suaeda maritima*, and tufts of *Puccinellia triflora* are other import plants of this zone. *Glaux maritima* and *Spergularia canadensis* also occur.

Zone 2 starts about 2 feet above normal high tide. *Plantago juncoides* is the most characteristic plant. Its chief associates at the lower level in the zone are *Puccinellia triflora* and *P. glabra*. These give way to *Triglochin maritima* higher in the zone. The number of associated plant species is greater than in Zone 1, including: *Elymus arenarius* on mounds, *Salicornia herbacea*, *Triglochin palustris*, *Ranunculus cymbalaria*, *Potentilla pacifica*, *Atriplex gmelini*, *Poa eminens* and *Chrysanthemum arcticum*.

Triglochin maritima and *Potentilla pacifica* are the characteristic plants of Zone 3. *Triglochin palustris*, *Carex glareosa*, *Poa eminens* and *Carex ramenskii* are the most prominent associates. Zone 4 contained *Elymus arenarius*, *Festuca rubra*, *Parnassia palustris*, and *Dodecatheon macrocarpum*. There are additional zones higher up which were progressively less marine oriented.

In Prince William Sound salt marsh communities contain similar species. *Carex lyngbyaei* which plays little part in Hanson's communities forms dense stands at the lower levels of marshes in Port Valdez. Pans on the marsh contain *Zannichellia palustris*.

Assessments of production have not been reported in the literature for Alaskan marshes. In this respect the knowledge of North Pacific salt marshes falls behind other areas.

Stephens and Billings (1967) have reported on a tidally influenced meadow at Kadashin on Chichagof Island, Alaska. They estimate that these meadows occupy less than 1% of the area in Southeastern Alaska. There are three prominent communities. A sedge community in which *Carex lyngbyaei*, dominates with *Potentilla anserina* and *Deschampsia atropurpurea* as associates is sited at the lowest level. *Deschampsia atropurpurea* is the dominant plant in the second zone. Its main associates are *Potentilla anserina*, *Elymus arenarius* and *Achillea*. In the upper zone, *Elymus arenarius* dominates with *Deschampsia atropurpurea* and *Achillea* as its principal associates.

The salt marshes of San Francisco Bay at Palo Alto were studied by Hinde (1954). He found a community zone between 5.4 and 8.4 feet above mean lower low water (M.L.L.W.) - mean higher high water level is 8.4 feet--which is dominated by *Spartina gracilis*. Above 8.4 feet *Salicornia pacifica* dominates up to 10.3 feet above M.L.L.W. Below the 8.4 foot line is a narrow ecotone where the dominants of the two zones intermingle. *Distichlis spicata* reaches its greatest density at the upper edge, 10.2 feet, of the *Salicornia* zone. It dominates the zone next above the *Salicornia* zone.

A general salt marsh type is found higher up (Chapman, 1960). *Distichlis spicata* and *Frankenia grandiflora* dominate one phase of it, the lower one. An upper phase contains Limonium commune, Atriplex leucophylla, Jaumea carnosa, and Grindelia.

The Grazing Link--The herbivores are the second link in the grazing food chain of the sea. The total energy uptake of these herbivores is of critical importance. It represents the total energy available to all trophic levels. This energy uptake is assimilation or gross secondary production. It is theoretically a simple matter to derive gross secondary production by subtracting feces produced from material ingested. In the laboratory it is simple in the sea it is not.

The most important herbivores in the sea are the zooplankton. The estimation of their biomass has to be based on a series of very carefully considered assumptions. McAllister (1969) following this course has derived an estimate of secondary production for phytoplankton at Ocean Station PAPA. His estimate is 13 g. C/m^2 year. This is approximately 27% of the value derived for primary production for the area. Sanger (1972a) assuming that the herbivore conversion efficiency is also 27% derived an annual production of .346 x10^9 tons of herbivore carbon per year for the Subarctic Pacific Region. He has also derived a zooplankton standing stock estimate of 98 x 10^7 tons for the region based on the volume of zooplankton in samples.

Grazing by littorine snails has been studied by Castenholz (1961). He found that a diatom carpet 0.5cm thick developed in 12-16 days. A littorine population with a volume of 0.2cm^3/dm^2 kept the test pools clear.

Benthic herbivores consistently overgraze, often to the point of almost eliminating their food source. Paine and Vadas (1969) studied the effect of grazing sea urchins on benthic algae at Friday Harbor, Washington. The removal of sea urchins from control plots brought about an increase in numbers of species of algae on these plots. The implication is that sea urchin grazing is sufficient to reduce species diversity.

Common pelagic herbivores include copepods, euphasiids, tunicates, pteropods and protozoans.

The Detritus Food Chain--All living and nonliving matter floating or swimming in the ocean is known collectively as seston. In some areas of the ocean the nonliving component may account for 40-90 percent of the total. This component is detritus. The detritus has two components, an inorganic component consisting of mud particles, silt, volcanic ash and calcareous or siliceous skeletons of dead phytoplankton and an organic component consisting of dead and decaying particles of formerly living organisms. The organic detritus present in the water may at times exceed the annual crop of all marine organisms by 10 to 100 times. In the northeast Pacific Ocean the organic detritus beneath a square meter of sea surface has been calculated to equal at least 500 grams dry weight (Thorson, 1971). Some 75-80% of this is in the upper 100-200 meters.

The organic detritus suspended in the ocean has only relatively recently been recognized as being an important component in marine food chains. It is the basis of one of the two food chains, the detritus food chain. While marine animals are often found with detritus in the digestive system it is normally the nutritive substrate for bacteria. The bacterial content of sea water is highly variable ranging from as few as 10 to as many as one million per millilitre. The role of the bacteria is twofold. They break down the detritus into organic plant nutrients and they are themselves food for other organisms.

The role of the detritus as a contributor of carbon in deep ocean food chains has its skeptics. Menzel and Goering (1966) noting the almost constant level of detritus in some water masses feel that the carbon in detritus is refractory or resistant to decay. There is a great deal of oceanic life at great depths, however, where there is no possibility of primary production which is the basis for the grazing food chain.

The dynamics and energetics of the deposit-feeding benthic polychaete, Pectinaria californiensis, in Puget Sound have been studied by Nichols (1975). Populations at five sample stations ranged from a low of 29-200/m² in May to 2,540-16,100/m² in July. At one station the primary production on the surface above the station was 460gC/m²/yr. The population ranged from 160-2,540 animals/m with a mean of 902/m². The population used 5.7gC/m² and secondary production was 2.8gC/m². At another station the population ranged from 150-4,620(mean 1,061), primary production was 275gC/m² of which the polychaetes utilized 9.2gC/m² to produce 4.8gC/m². The polychaetes utilized 1.2% of the primary production at the first station and 3.3% at the second. They passed on 0.6% and 1.7% of the total surface carbon to consumers at the next trophic level. The relative importance of this species is readily apparent from the above figures.

Invertebrates--The invertebrate life in the sea is rich and diverse. It is not possible to treat it comprehensively within the scope of this statement. The following general treatment of habitats is based on conditions in Puget Sound and the Strait of Georgia (Kozloff, 1973).

Wooden pilings, floats of wood, fiberglass, styrofoam and concrete form a suitable substrate for the attachment of many kinds of algae and invertebrates. There are also a number of unattached forms which can be found associated with pilings and floats, usually at night.

These attached or associated animals are from the following groups: protozoa, sponges, cnidarians (hydroids, jellyfishes, and sea anemones),comb jellies, flatworms, nemertians, polychaete annelids, bryozoans, crustaceans (planktonic copepods, amphipods, isopods, shrimps, crabs and barnacles), molluscs (chitons, limpets, sea slugs, bivalves, and squids), and echinoderms (sea stars, sea cucumbers, sea urchins, chaetognaths).

The rocky intertidal area is a highly variable type of habitat reflecting differences in rocks, currents, exposure to winds and tides and in salinity due to fresh water influx. In spite of this definite zones influenced basically by the differing tolerance of various organisms to exposure by the tidal fluctuations are formed.

Tide pools and narrow guts and channels which magnify wave action will cause apparent variations but the zones are usually readily apparent.

The highest zone is the supralittoral fringe. It derives its moisture from salt spray and rain. The invertetrates fauna is limited to littorine snails, barnacles, and isopods. Vegetation is limited with the lichens Verrucaria and Caloplaca the most obvious components. A crustose bluegreen algae, Calothrix, is also characteristic.

The second zone is the upper midlittoral. The rockweed, Fucus distichus, is the most prominent brown algae and Endocladia muricata the most characteristic molluscs (littorines, limpets and thias) and crustaceans (barnacles, hermit crabs and isopods). The littorines and limpets are herbivores. The thais are carnivores.

The third zone, just above mean lower low water, is the lower midlittoral. The common representative algae are green (Ulva), brown (Hedophyllum) and red (Halosaccion). The common animal groups are bivalve molluscs (mussels, gastrapods (limpets and thias), chitons, crustaceans (goose barnacles, crabs and hermit crabs), starfish, and sea anemones.

The fourth zone, the infralittoral fringe, is exposed only at very low tides. Characteristic plants in this zone are surfgrass, Phyllospadix scouleri, brown algae, represented by a variety of laminarians, and coralline red algae. The invertebrate fauna includes: sponges, cnidarians (hydroids and sea anemones), flatworms, peanut worms, polychaetes, echinoderms (sea stars, brittle stars, sea urchins and sea cucumbers), brachypods and molluscs (chitons, snails, limpets, tritons, abalones and sea slugs). This invertebrate congregation includes omnivores, herbivores and carnivores.

Sandy beaches, quiet bays and subtidal areas have different invertebrate faunas consisting of the same groups found on the rocky intertidal areas but their composition varies depending on the requirements of the various taxa. The midwater and abyssal areas of the deep ocean have their own specialized invertebrate faunas which are variations of the same general theme. Below the photic zone these communities are not associated with vegetation as they are within the areas discussed above.

The third link in the grazing food chain which is found in close proximity to the herbivores in the second link is constituted primarily by zooplankton. These plankton include representatives of almost every animal group living in the sea, many of them vertebrates. Among those which are most prominent are: foramenifera, radiolarians, worms, arrowworms, steropods, salphs, copepods, euphasiids, larval crustaceans (crab, shrimp and lobster), medusae, heteropods, ctenophores and fish larvae. Fish eggs are also passive zooplankton.

The most important zooplankton are the crustaceans. One group of these, the copepods, is so numerous that it is thought by Sir Allistar Hardy to exceed in abundance all other multicelluluar organisms combined. In the northwestern Pacific copepod densities of 15,000 per cubic meter of sea water have been found (Thorson, 1971). Greater densities have been found elsewhere. One copepod, "brit," Calanus finmarchus, is considered to be the most important animal in the world. Another key member of the zooplankton community is the euphasiid. This omnivorous crustacean, called "krill," is the food of the baleen whales. One species of euphasiid has been calculated to have an annual production of 100 million metric tons. This is twice the annual yield of the world's commercial fisheries (Thorson, 1971).

The zooplankton biomass in the Bering Sea in early summer ranges from 67.1 g/m² in the top 80 meters around the Pribilofs to 22.8-28.4 g/m² in the vicinity of Bower's Bank. The central part of the Bering Sea has a relatively low biomass and on the continental shelf biomass increases from north to south (Motada and Minoda, 1974).

Sanger (1972a) has derived an estimate of primary carnivore production of 93.42 x 10 tons annually for the Subarctic Pacific Region.

Many invertebrates are of direct importance to man. Subsistence use is much less extensive than it formerly was. Eskomos catch crab at the edge of the ice in late winter. Clams taken from walrus stomachs are much relished by Eskimos from walrus hunting areas. They are also said to use small "shrimps," probably euphasiids, in soups (Nelson, 1969).

King crab, Dunginess crab, and shrimp are much sought by sport fishermen in Alaskan Coastal waters. In the northern Gulf of Alaska razor clams, cockles, Washington clams and geoducks provide good sport and excellent food. In Southeastern Alaska and British Columbia shellfish must be used with caution because of periodic shellfish poisoning. Clams and crabs are very popular in the Pacific Northwest. The State of Washington has estimated that 634,000 clam diggers harvested 9 million clams in 1968.

Buck (1973) has compiled historical catch statistics through 1969 for the Subarctic North Pacific Region north of Washington. The harvest discussion which follows is derived from this source and the final environmental impact statement for the Trans-Alaska Pipeline (U.S.D.O.I., 1972).

Japan initiated the king crab fishery in the 1930's. The United States entered in 1948 and the U.S.S.R. in 1959. The fishery is dominated by the United States except in the Eastern Bering Sea. A total of 1,431.9 million pounds have been taken in the fishery, largely since 1960. The peak harvest year was 1966. The maximum sustained yield (MSY) is estimated to be about 65 million pounds annually. Between 1965 and 1969 the value of wholesale king crab products dropped from $27.8 million to $15.2 million but averaged $23.3 million.

Dungeness crab provide a base for a relatively stable fishery. The catch remained relatively constant during the decade of the 1960's. Between 1965 and 1969 products ranged in value between $1.8 million and $3 million, with an annual average of $2.6 million. The MSY for Dungeness crab is estimated at about 30 million pounds annually. In Prince William Sound the harvest has exceeded 2 million pounds in recent years.

The tanner crab fishery was virtually nonexistent before 1967. Products worth $195,000 were manufactured from Gulf of Alaska stocks in that year. The fishery has been dominated by the Japanese who have taken just slightly less than three-fourths of the harvest between 1964 and 1969. The harvest has been greatest in the Bering Sea but it is moving east. A total of 180.5 million pounds were taken during the five year span 1964-1969. The MSY is estimated to be 200 million pounds annually.

Six species of Pandalid shrimp are common in commercial landings. The combined maximum sustained yield (MSY) for the Gulf of Alaska is believed to be about 100 million pounds annually. The Bering Sea fishery is dominated by Japan. A total of 260.2 million tons were harvested there between 1960 and 1969. The fishery in the Gulf of Alaska is dominated by the United States with the U.S.S.R. second and Japan third. The catch from 1959 to 1969 has been 307.9 million pounds. Some 135 million pounds have been taken from remaining Alaska waters between 1920 and 1969. Canadian fishermen took 28.6 million pounds in British Columbia waters between 1951 and 1969.

Other invertebrates of commercial interest found in the Gulf of Alaska are clams with an estimated MSY of 50 million pounds annual abalone, and scallops. The abalone and scallops do not appear to be able to support a significant fishery. Razor clams sustained a harvest of more than 1 million pounds annually in Prince William Sound from 1916 to 1962. There has been no major cannery there since 1962.

Fish--The component of the marine ecosystem with the most apparent economic importance is the one including fish and shellfish of commercial importance tc man.

The fish fauna of the Bering Sea consists of about 45 families containing some 300 species (Wilimovsky, 1974). Almost three-quarters of the total species are from 8 families. Many families are represented by only one species and others by only a few.

The fish stocks in the Bering Sea are currently the most important stocks in the world. They are heavily exploited by Japan, Russia, and the United States. The catch of benthic species has increased a hundred fold from 4 x 10 to 4 x 10 metric tons between 1954 and 1969. Some of the commercially important fish in the Bering Sea are herring, pink salmon, coho salmon, chinook salmon, chum salmon, sockeye salmon, pollock, Pacific cod, Pacific ocean perch, black cod, halibut, yellowfin sole and sablefish. Another species, the Pacific hake, is currently the most heavily utilized species in the world catch.

The Bering Sea contains also a variety of other species. These include: lampreys, sturgeons, inconnu, ciscos, whitefishes, steelhead, Arctic char, Dolly Varden, smelts, burbot, Arctic cod, saffron cod, sticklebacks, sculpins, a number of additional flatfishes and other fish of considerable importance to seabirds and other fish.

Fish common to the Arctic bottom are found in cold, dense waters at great depths far from the Arctic. The sable fish which is an important commercial fish in Alaska and British Columbian waters occurs in waters 1,400 meters deep off Baja California.

Fishes in Cook Inlet include Chinook, sockeye, pink, coho, and chum salmon, halibut, butter sole, yellowfin sole, turbot, pollock, steelhead, Dolly Varden, eulachon, and herring plus other fish of less commercial value.

Hart (1973) lists 325 species of fish which occur in British Columbia Coastal waters, 13 of these are northern fishes reaching their southern limit and 53 are southern fish reaching their northern limit. Most of these fish are also found in United States coastal waters in the Gulf of Alaska and off the Pacific Coast. Some of these are, as follows: sharks, rays, herring, salmon (pink, chum, coho, sockeye, and chinook), steelhead, cutthroat trout, Dolly Varden, smelts, cod, stripped bass, barracuda, gobies, gunnels, sand lance, bonita, chub mackeral, rockfishes, sablefish, greenling, sculpins, snailfish, petrale sole, rex sole, haibut, buttersole, rock sole, and dover sole.

These fish exhibit a wide variety of breeding habits. Several are anadromous, leaving the sea to spawn in freshwater. These are principally salmon, trout, char, smelt, lampreys and sturgeon. Some bear living young (viz. some of the sharks, skates, and rays, surfperches and blennies) in contrast to those whose eggs develop and hatch outside the adult's body. Although diversity is an asset to the species, it vastly complicates our ability to forecast impacts from the present knowledge base.

Every type of fish habitat is utilized by fish along this coast. Fish like the Dolly Varden and inconnu are usually found in brackish water in estuaries and stream discharge plumes. Tide pools in the intertidal zone contain gobies, blennies and often greenling. Shallow water bottom areas with sandy or muddy substrate are usually occupied by fish without swim bladders such as flatfishes and rays.

Rocky ledges and reefs are shelter for fish like lingcod and the many rockfishes. Cobbled bottoms are favored by lumpsuckers. Steelhead, salmon, tuna, pomfrets, albacore, yellowtail, anchovies and herring forage in the surface waters. Deep water bottoms are favored by cold water fish like the sablefish.

Sportfishing for anadromous and marine fish is growing rapidly throughout the North Pacific Coast area. Historically salmon, char, trout and halibut have been of the most interest to anglers. In recent years the interest has broadened and other fishes are being added to the catch. The composition of the catch is variable from region to region. Many excellent food fishes are still relatively untouched.

In Cook Inlet fishermen pursue pink, chum, coho, sockeye and chinook salmon, Dolly Varden, steelhead, halibut and eulachon. On the outside coast rockfishes, greenling and lingcod are popular. In Prince William Sound cutthroat trout, starry flounder and dogfish shark are caught.

Little statistical data are available. Only the chinook salmon sport fishery has been examined critically. The chinook salmon sport fishery in Cook Inlet has been faced with bag quotas and restricted seasons since 1963. During the period 1966-69, 2,000 chinooks were taken in four Upper Cook Inlet streams and 1,900 from four streams on the Kenai Peninsula. The salt water fishery for the same species has been increasing with 200 taken in 1972. and 2,200 taken in 1972. In 1973 fishermen on Kenai Peninsula beaches took 1,030 chinook with 8,220 man days of effort. Spawning escapement, is the principal parameter utilized in managing Alaska salmon in general and it provides little insight into sport fishing harvest.

Southeastern Alaskan British Columbian waters still provide enough halibut for local anglers and the take of other fish is limited. The anglers of Washington and Oregon still prefer salmon but other fish are sought as salmon become more difficult to catch. Albacore, halibut, cod, lingcod, greenling, sharks, and many rockfishes are now included in the catch. Sport fishermen in British Columbia waters caught an estimated 281,000 salmon in 1969. A 1965 survey of sport fishing indicated that 999,000 anglers caught 38.5 million fish along the Pacific Coast from Point Conception north.

In spite of its great population close to the sea large stretches of California's coastline are virtually unfished. Moro Bay is an exception. Lingcod, blue rockfish, halibut, jacksmelt, and seasonally albacore and salmon are caught in the relatively well developed local fishery. Other areas like San Francisco Bay and the outside coast south to Monterey are now developing. In southern California waters anglers take 1.1 million croakers and 1.9 million tuna annually.

There are two broad commercial fisheries in the North Pacific, the nearshore fishery out to 12 miles is usually dominated by local fishermen, and the high seas fishery is international. Japan and the USSR are very prominent in the region's high seas fishery.

The following discussion of historical catch and harvest value is derived from Buck (1973) and USDI (1972) for the North Pacific north of Washington.

Canada has historically dominated the herring fishery. In the years since 1963 the center of harvest has shifted to the Bering Sea and the USSR has achieved total supremacy in the fishery. The total historical catch from the 1880's to 1969 was 23,965.2 million pounds. A recent development has been the "herring-eggs-on-kelp" fishery. This centers in Prince William Sound which has an annual production of nearly a quarter million dollars. This is a potentially destructive fishery in that it is disruptive to salmon food chains and destroys kelp cover.

Historically salmon have dominated the nearshore fishery. Pink salmon have contributed most, 11,264.6 million pounds; followed by sockeye, 10,384.4 million; chum, 6,836.1 million; coho, 2,284.4 million; and chinook, 1,285.6 million. In Bristol Bay the sockeye salmon has dominated the fishery. The peak year in this fishery was 1938 and the total historical catch to 1969 was 4,716.7 million pounds. The catch is declining and has been so poor in recent years that the area is economically depressed. Spawning and rearing areas are virtually intact and good management could still restore this fishery as well as other Alaskan salmon fisheries.

Nearshore fisheries in the Gulf of Alaska east of Unimak Pass amounted to about $59.5 million annually between 1965 and 1969 and were 9 percent of total U.S. landings in 1969. Salmon continue to be the economic mainstay of the fisheries of this region, with annual catches during the past ranging in value from $17.7 million to $41.6 million. The maximum sustained yield (MSY) for all species of salmon in the Gulf of Alaska is estimated to be 300 million pounds annually.

Pacific halibut have supported a substantial United States and Canadian fishery. During 1960's landings at Gulf of Alaska ports were about 24 million pounds annually. During this time British Columbia led all other Canadian provinces in volume and value of fish landed. Halibut along with salmon and herring contributed much to this record catch.

In 1969 the total fishery landings of Washington, Oregon, and California amounted to 803 million pounds and produced a gross income to the fishermen of $107 million. Total fishery landings in the San Francisco area in 1969 amounted to nearly 9 million pounds worth about $2.4 million. Salmon provided the base for the Puget Sound Basin's most important fishery. During 1969 the catch was 42 million pounds and had a value of $15 million.

High seas fisheries are important in the offshore waters of the North Pacific region, particularly in the Bering Sea. Important fish in the catch are: pollock with a total catch of 12,612.3 million pounds mostly since 1963, Pacific cod, 1,247.1 million; Pacific Ocean perch, 4,573.6 million; black cod (sablefish); 803.1 million; and halibut, 3,630.6 million.

Fisheries are conducted in the offshore waters south of Canada by the Soviet Union, Japan, Canada and the United States. Principal species fished are: Soviet Union--hake; Japan--rockfishes, sablefish, saury; Canada--salmon; and the United States--salmon, tuna. The Soviet hake fishery lasts from April to November as trawlers follow the Northern California to Vancouver Island migration. An incidental catch of rockfishes is also taken. The Japanese fishery consists of rockfish trawlers and sablefish longliners.

Marine Mammals--Sea otters are common throughout the Aleutian Islands from the Rat Islands eastward. A small "pelagic" population makes its home in southern Bristol Bay where it is periodically devastated by extreme advances of the pack ice. Along the southern coast of the Alaska Peninsula they have increased to the point that they have seriously depleted some of their prey populations like the razor clam. The Alaska Department of Fish and Game (1973) estimates that there are 30,000-40,000 in the Alaska Peninsula and Unimak Island waters (ADFG, 1973). West of Unimak Island, there are an estimated 59,000-70,000 animals. There are presently estimated to be 4,000 in Prince William Sound with the bulk of these just south of Hinchinbrook Entrance and around the Gravina Point area. In recent years, sea otters have been transplanted to Southeastern Alaska, British Columbia, Washington and Oregon. A remnant population of about 1,700 animals extends from Monterey Bay to Moro Bay on the California Coast.

The northern fur seal is the most truly pelagic of North Pacific seals. It rarely hauls out except to breed. Of the current population of 1.6 million animals 1.2 million breed on the Pribilof Islands (USDOC, 1974). Another herd of less than 1,000 animals has recently been discovered breeding on San Miguel Island in the California Channel Islands. Away from the Pribilofs they range widely over the North Pacific and south along the Pacific Coast as far as Mexico.

A remnant population of less than 1,000 Guadelupe fur seals breeds on Guadelupe Island, Mexico. They are seen very rarely as far north as the Channel Islands.

Northern sea lions breed and range from the Sea of Japan to the California Channel Islands. The current world population is estimated to be 240,000-300,000 of which more than 200,000 are in Alaskan waters (USDOC, 1974). They are relatively sedentary and are seldom found more than 15 miles offshore. About 28,500 sea lions use rookeries and haulouts adjacent to Unimak Pass. The Ugamak Island rookery adjacent to the Pass is the second largest known colony, about 13,400 animals. There are about 6,500 animals at Amukta Pass and another 3,000 at Amchitka Pass.

California sea lions are most abundant along the California and Baja California coasts and coastal islands but range as far north as Vancouver. The total population is estimated to be 60,000 animals 40,000 of which are in California waters (USDOC, 1974).

Pacific walruses winter in the Bering Sea, concentrated in the Western Bering Sea around St. Lawrence Island and in central Bristol Bay. The only remaining summer hauling ground in the United States is at the Walrus Islands in Bristol Bay where 1,500-2,000 animals spent the summer of 1958. Most of the herd passes out into the Chukchi Sea with the receding pack ice. The walrus' special diet of clams restricts the areas and water depths over which they can range. They usually feed in waters less than 240 feet deep. Kenyon estimates that the current population has a median size of 135,000 animals (USDOI, 1974).

Harbor seals are the most widespread of any inshore seal in the North Pacific area ranging, in the east, from Baja California to the Beaufort Sea. The current estimate for the total North Pacific population is 750,000 animals. This seal breeds on secluded beaches and offshore rocks throughout their range. One group, sometimes accorded subspecific status, breeds on the ice of the Bering Sea.

Bearded seals are widely distributed throughout the Bering, Okhotsk and northern Japan Seas and have a circumpolar range in the Arctic Ocean. Some of the immature animals remain in the Bering Sea in summer but most move north with the pack ice. There are estimated to be 300,000 animals in the Beaufort, Chukchi, Bering and East Siberian Seas (USDOC, 1974).

Ringed seals are found throughout the Arctic whenever seasonal or permanent ice is found. They live under the ice by maintaining breathing holes. The Bering-Chukchi Sea population is estimated at 250,000 animals (USDOC, 1974).

Ribbon seals are separable into two populations one in the Okhotsk Sea and the other in the Bering Sea. Commercial sealing on the Russian coast has reduced the population in recent years. The world population is probably less than 100,000 (USDOC, 1974). Their habits are similar to those of harbor seals.

Northern elephant seals breed from Cabo San Lazaro, Baja California to Point Reyes, California. Their total population is estimated to be about 30,000 animals (USDOC, 1974).

The eastern North Pacific population of black right whale ranges from Bristol Bay to Baja California. There are presently 250 animals in this population (USDOC, 1974).

Bowhead whales from the population found in Alaskan waters winter in the drift ice zone at the edge of the ice pack. They summer in the Arctic Ocean. There is no present basis for making a population estimate. The numbers are not large.

The eastern Pacific gray whale population summers in the northern Bering, Chukchi and western Beaufort Seas migrating to west coast of Baja California and the southern Gulf of California to winter. The population now appears stable at about 11,000 animals.

Minke whales inhabit all oceans. The North Pacific Ocean population ranges from the Chukchi Sea to northern Baja California during the summer and from central California to Islas Revillagigedo, Mexico in the winter. No population estimates are available.

The sei whale ranges over much of the worlds' oceans. In the eastern North Pacific it summers from the Aleutians and Gulf of Alaska to California. There are estimated to be between 33,000 and 37,000 in the North Pacific Ocean (USDOC, 1974).

The fin whale also has a nearly world wide distribution. In the eastern North Pacific it summers from the Chukchi Sea to California. It winters farther south. Current estimates place the North Pacific stock at 10,000 to 13,000 (USDOC, 1974).

The blue whale ranges through all the world's oceans summering in high latitudes and wintering in low latitudes. The population in the eastern North Pacific ranges from the Aleutian Islands and the Gulf of Alaska south to central California in the summer and from central Baja California to southern Sinaloa, Mexico during the winter. The population in the North Pacific now numbers about 1,500 animals (USDOC, 1974).

The humpback whale is found in tropical and temperate oceans world wide. The North Pacific population ranges from the Chukchi Sea to southern California in summer and from there south to Islas Revillagigedo and around the Hawaiian Islands in winter. This population has been severely depleted and numbers about 1,200 animals (USDOC, 1974).

Sperm whales have nearly a world wide distribution. They occur as far north as the Bering Sea but avoid the ice. Currently it is the most important species in the international whale fishery. The commercial stock estimate is 70,000 males and 184,000 females in the North Pacific (USDOC, 1974).

Several smaller whales also occur in Pacific Coastal waters. The pygmy sperm whale ranges north as far as Washington. The dwarf sperm whale has been recorded off San Luis Obispo County. The Bering Sea beaked whale is a North Pacific endemic species. On the eastern side it ranges from the Pribilofs to Oregon. It is rare. The arch-beaked whale, another endemic, is found in the east from British Columbia to southern California. The goose-beaked whale is found in all the worlds temperate and tropical oceans. In the eastern North Pacific it ranges north as far as the Aleutians. Its status is unknown. The giant bottle-nosed whale is also endemic to the

North Pacific. In eastern North Pacific waters it ranges from St. Matthew Island in the Bering Sea to southern California.

The beluga is an Arctic whale. There are two populations in the eastern North Pacific area one occurs off the northern and western Alaska Coast as far south as Bristol Bay and as far west as Amchitka Pass, the other is in Cook Inlet. There are 300 to 500 whales in Cook Inlet, 1,000-1,500 in Bristol Bay and an estimated total population in Alaskan waters of 3,000-5,000 animals.

There are nine ocean dolphins which occur in Pacific coast waters between Golovin Bay and Point Conception. These are, the: bottlenose, Risso's, Pacific white-sided, striped, common, and northern right whale dolphins and the short-finned pilot, false killer and killer whales. Their ranges vary from very restricted to very general. They vary in number from the rare false killer whale to the abundant Pacific whitesided dolphin.

One other marine mammal, the polar bear, occurs at the very fringe of our discussion area. It ranges as far south as St. Lawrence Island and occasionally even as far as St. Matthew Island. There are never many south of the Chukchi Sea.

Eight of the great whales discussed above are listed as endangered species on the United States list. These are, the: Blue, bowhead, fin, gray, humpback, right, sei and sperm whales. Several others are so rare that their status cannot be determined. They are not listed, however, as the rarity apparently does not represent an abnormal phenomenon. The harvest of marine mammals is undergoing several restrictive changes, some species continuing to meet commercial and subsistence demands.

The polar bear has been traditionally hunted by Arctic Eskimos for hides, food and tendons. The harvest limited to subsistence hunting by natives, was 7 in 1973 and 40 in 1974.

There is no legal private harvest of sea otters. The only harvest in recent years has been a periodic hunt by the State of Alaska. Between 1962 and 1969 a total of 2,933 pelts were taken for sale.

The Pacific walrus is hunted in Alaska and Siberia. Siberian and Alaskan natives kill from 5,000 to 6,000 walrus annually for subsistence purposes.

The northern sea lion is not harvested currently.

The northern fur seal is still harvested. During, 1973, 28,457 of these seals were harvested. Harbor seals, ringed seals, ribbon seals, and bearded seals are harvested only by Alaskan Eskimos. Harvest records are not available.

The bowhead whale is taken by Alaskan Eskimos. Harvests during the last 20 years, have ranged from 1 to 37 animals. Grey whales are taken by Eskimos when the opportunity arises, usually never more than three in a year. The Siberian subsistence kill for 1972 was 181 individuals (USDOC, 1974). No recent estimates of belugas harvested in any one year has been made. Lensink estimated the total kill for 1962 to be 400-500 animals. Killer whales are sought and taken as display animals in the United States. Bottle-nosed dolphins are also much sought for display collections. Numbers taken are not available for these two species.

The commercial harvest of whales in the North Pacific in 1971 by country and species, was as follows: Russia--190 fin, 296 sei, 5,525 sperm, and 638 others for a total of 6,163 whales; Japan--608 fin, 2,707 sei, 5,131 sperm, and 270 others for a total of 8,716. The grand total of whales harvested by both countries during 1971 was 14,879 whales (Parker, 1974).

Birds--The coastal and pelagic waters from Alaska to southern California are regularly frequented by some 200 species of birds. This large group of birds can be separated into breeders, visitors and passage migrants. Passage migrants which do not linger in the marine environment are outside of the scope of this discussion. A visitor is any bird which comes to the sea for a part of the year or a part of its life but breeds elsewhere. Breeders are those which breed in the marine environment either on islands or on coasts facing the sea. The question of which group a particular species belongs to, however, can be rather a sticky one to answer at times.

The marine range of seabirds can be subdivided into several general habitats based on water depth, distance from shore, water temperature and salinity. The division of the ocean into pelagic and neritic waters is valid for seabirds as it is for most other sea life. Wynne-Edwards has divided neritic waters into two zones (a) an inshore zone extending from high water offshore for 6-8 km, and (b) an offshore zone extending from there to the edge of the continental shelf (Ashmole, 1971). Water depth appears to exert a greater influence on the outer limit of the inshore zone than was apparent in areas where Wynne-Edwards worked. In the Gulf of Alaska inshore species can be found in greatest density inside of the 50 fathom curve regardless of its distance from shore (USFWS, unpublished data). Sanger (1972b) has divided the pelagic waters in the Subarctic Pacific Region into several surface domains using salinity and temperature as base parameters. His zonation of pelagic waters is, as follows: Western Subarctic Domain, Central Subarctic Domain, Transitional Domain and Coastal Domain (Figure 8.2.1.-23). Sanger considered the shelf waters of the Bering Sea as a separate Bering Sea Coastal Domain and separated out the waters off California as California Coastal Waters.

Table 8.2.1.-20 shows the distribution of sixty-three species of birds belonging to nine families and 28 genera which have more or less regular occurrences within the region. Loons, grebes, shorebirds (except phalaropes) and marine waterfowl are mostly restricted to the littoral and are not included in the table. In addition, there are raptors which if not seabirds are certainly associates.

Sanger (1972 b) has derived standing stocks of seabirds in the Subarctic Pacific Region based on observations made at sea. He has recently revised his thinking on the visibility of birds at sea and feels that the figures in the literature are about 50% low. Table 8.2.1.-21 reflects this new thinking.

Three albatrosses are visitors to the region. Their breeding grounds are to the south of the area. Non-breeding birds are present year around. The Laysan albatross is most common in the Western Subarctic. The black-footed albatross is a common species in the eastern Pacific. The short-tailed albatross once abundant in the eastern Pacific was nearly extinct in the last century and is now an endangered species. There are probably only 100 or so birds in the world population presently. Sanger (1972) has listed five sightings and one questionable sighting off the west coast from the Gulf of Alaska to San Francisco between 1940 and 1970. There is also one positive sighting of an adult by Sowl in Amchitka Pass on May 28, 1968. The albatrosses are surface feeders eating fish, squid and refuse from ships.

Table 8.2.1-20 Seabirds of the subarctic Pacific region

Species	Bering Sea Coastal	Coastal	Calif. Cstl. Waters	Western Subarctic	Central Subarctic	Transitional
Albatrosses						
Short-tailed Albatross		X		X	?	X
Black-footed Albatross	X	X	X	X	X	X
Laysan Albatross	X	X		X	X	X
Shearwaters, etc.						
Fulmar	X	X	X	X	X	X
Pink-footed Shearwater		X	X			X
Pale-footed Shearwater	X	X	X	X	X	X
New Zealand Shearwater		X	X	X		X
Sooty Shearwater	X	X	X	X	X	X
Short-tailed Shearwater	X	X	X	X	X	X
Manx Shearwater	X	X				X
Motley-faced Shearwater				X		
Scaled Petrel		X		X	X	X
Cook's Petrel		X				
Storm-Petrels						
Fork-tailed Storm-petrel	X	X	X	X	X	X
Leach's Storm-petrel	X	X	X	X	X	X
Ashy Storm-petrel			X			X
Black Storm-petrel			X			X
Pelicans						
Brown Pelican		X	X			
Cormorants						
Double-crested Cormorant		X	X			X
Brandt's Cormorant		X	X			X
Pelagic Cormorant	X	X	X			
Red-faced Cormorant	X	X				
Phalaropes						
Red Phalarope	X	X	X	X	X	X
Northern Phalarope	X	X	X	X	X	X
Jaegers, Skua						
Pomarine Jaeger	X	X	X	X	X	X
Parasitic Jaeger	X	X	X	X	X	X
Long-tailed Jaeger	X	X		X	X	X
Skua		X		X	X	X
Gulls, Terns						
Black-tailed Gull				X		
Glaucous Gull	X	X		X	X	
Glaucous-winged Gull	X	X	X	X	X	X
Slaty-backed Gull	X	X		X		
Western Gull		X	X			X
Herring Gull	X	X	X	X	X	X
California Gull		X	X			
Ring-billed Gull		X	X			
Mew Gull	X	X	X	X		
Bonaparte's Gull		X	X			
Heerman's Gull		X	X			
Black-legged Kittiwake	X	X	X	X	X	X
Red-legged Kittiwake	X	X		X		
Ross' Gull	X					
Sabine's Gull	X	X	X	X		X
Common Tern		X	X	X		
Arctic Tern	X	X	X	X	X	X
Aleutian Tern		X		X		
Murres, Auklets, etc.						
Dovkie	X					
Common Murre	X	X	X	X	X	X
Thick-billed Murre	X	X		X	X	
Black Guillemot	X					
Pigeon Guillemot	X	X	X	X		
Spectacled Guillemot				X		
Marbled Murrelet		X	X			
Kittlitz's Murrelet	X	X				
Xantus' Murrelet		X	X			X
Ancient Murrelet		X	X	X	X	X
Cassin's Auklet		X	X		X	X
Parakeet Auklet	X	X		X	X	
Crested Auklet	X	X		X	X	
Least Auklet	X	X		X		
Whiskered Auklet				X		
Rhinoceros Auklet	X	X	X	X	X	X
Horned Puffin	X	X		X	X	X
Tufted Puffin	X	X	X	X	X	X

Table 8.2.1-21 Estimated seabird numbers in the subarctic Pacific region

Surface Domains	Area	Birds per 100 km^2	Standing stock	Birds per 100 km^2	Standing stock
Coastal	1.36×10^6 km^2	322	4,374,000	1,557	21,166,000
California Coastal Waters	0.02×10^6 km^2	2,611	419,000	2,611	419,000
Bering Sea Coastal	1.00×10^6 km^2	---	---	1,557	21,166,000
Central Subarctic	3.79×10^6 km^2	113	4,289,000	878	33,362,000
Western Subarctic	3.69×10^6 km^2	112	4,123,000	618	23,135,000
Transition	2.46×10^6 km^2	91	2,146,000	91	2,146,000
Grand Totals			15,351,000		101,395,000

After Sanger

Of the 10 shearwaters and petrels found in the Subarctic North Pacific region, only 1, the northern fulmar, is a breeder. While some shearwaters can be found in the Transition and southern Coastal Domain waters in winter, most of these birds are far to the south near their southern hemisphere breeding grounds. Short-tailed and sooty shearwaters are the most numerous species. Shuntov (1964) has reported densities of 5,000 short-tailed shearwaters per square kilometer in the Bering Sea in summer. Flocks estimated to number several millions have frequently been encountered in Unimak Pass in late summer. Small fishes, euphasiids and squids are the most frequently reported foods. Ogi and Tsujita (1973) found that the stomach contents of short-tailed shearwaters in the Bering Sea were composed principally of euphasiids.

Of the 4 storm-petrels found within the region, only the fork-tail and Leach's are common. In Alaskan waters the fork-tail is the most abundant and the only species that remains year around. Food consists of small fishes, molluscs, euphasiids and copepods captured on the surface.

The brown pelican has historically been a common bird in California Coastal waters. It is a fish eater. In recent years its breeding success has been drastically impacted by chlorinated hydrocarbon pesticides and it is now listed as an endangered species.

The comorants are inshore zone inhabitants. They feed almost exclusively on fish and will dive to considerable depth to obtain them. Cormorant populations in the Gulf of Alaska appear to be in a state of flux at the present time with red-faced cormorants moving eastward and Brandt's cormorants moving northward and westward. Pelagic cormorants appear to have been replaced at least temporarily in some rookeries and gathering spots. The significance of these events is not apparent but it does raise the possibility that additional environmental stress could have greater impact than would usually be the case.

Red and northern phalaropes, although technically shorebirds and only seasonal visitors to the marine environment, are among the most pelagic of birds. They are extremely abundant. Their food consists of relatively small plankton.

The jaegers are passage migrants and can be quite common during their migrations. Skuas appear only very rarely in the northern part of the region. Both Jaegers and skuas obtain much of their food by pirating fish from gulls and terns.

There are a large number of gulls, 15, found within the region. They include within their number breeders, passage migrants, and seasonal visitors. Three terns also occur there. They feed most intensively on fish, but eat invertebrates, garbage and carrion as well. Gulls are primarily confined to littoral areas during the summer but some are highly pelagic in the winter. This is particularly true of the kittiwakes, the most pelagic in habit of any birds in the family Laridae. The redlegged kittiwake is endemic to the Bering Sea.

The family Alcidae has its center of greatest diversity within the Bering Sea region. All but 4 of the 22 existing species occur within the Subarctic Pacific region. They vary widely in distribution, numbers, anatomy and habits. We do not know nearly enough about the ecology and population dynamics of most of the birds in this group. For some of them it is all but impossible to obtain an estimate of population size. Most are largely confined to the coastal domains but the tufted puffin can be found far offshore in some of the worst weather imaginable. They feed, depending on the species, on a variety of planktonic crustaceans and small fish.

Ogi and Tsujita (1973) have reported on the stomach contents of murres caught in salmon drift gill nets in Bristol Bay. The contents consisted of fishes, euphasiids, squids, and amphipods in that order. Identified fishes were walleye pollock, Pacific sandlance and capelin. No effort was made to distinguish between the two species of murres and food distribution has found to be patchy.

In addition to the groups already discussed, there are a number of birds which live so closely tied to the marine environment that they must also be considered. The Peale's race of the peregrine falcon is an uncommon but so far not endangered inhabitant of coastal regions. It is quite commonly found in association with colonies of small alcids. Its range extends several kilometers offshore. The bald eagle is also found throughout most of the coastal zone area adjacent to the Subarctic Pacific Region. It is nominally a fish eater but in some areas of its range it feeds its young on seabirds. The northern bald eagle is not endangered but the southern race found south of 40°N is endangered.

A number of waterfowl are also closely associated with the marine environment. These include old squaws, eiders, goldeneyes, scaups, scoters, mergansers, emperor geese and black brant. These birds are classified as seasonal visitors to the marine environment. Non-breeders of all species can be found in the marine environment year around. The common eider is, however, much more of a true seabird than many of the species listed in Table 8.2.1.-20. Food is variable including fish, invertebrates and flowering plants like eelgrass and horned pondweed.

A number of shorebirds are either passage migrants or full-time inhabitants of the littoral. The shorebirds with the greatest affinity for the marine margin are the black oystercatcher, surfbird, black turnstone and rock sandpiper. Probably the most abundant of the passage migrants is the western sandpiper. More than a million birds of this species are pushed out of the mudflats at Orca Inlet on Prince William Sound on each high tide during the peak of the spring migration. Diets are variable but invertebrates are most common food items.

Areas such as the Yukon Delta, Chagvan Bay, Izembek Lagoon, the Susitna Flats, the Chickaloon Flats, Unimak Pass, Orca Inlet, the Copper River Flats and Stikine Flats are key points in the annual migrations of many species of birds entering and leaving the Arctic. Several of these areas serve as migration funnels and serious environmental degradation or catastrophic occurrences at critical times would have serious implications for many of the zoo species living on or migrating along the Pacific Coast.

The north central and northeastern coast of Prince William Sound has the highest nesting density of bald eagles in south central Alaska. In the vicinity of the Point Gravina site 16 active nests were found between Gravina Head and Sheep Point during surveys in 1973 (USFWS, unpublished data). None of these nests is farther than 5 miles from the potential site and all face directly onto the area of greatest concentration of vessel traffic associated with the site.

Sea birds and their eggs were once used extensively by Alaskan natives. This subsistence use continues at a relatively low level. There is no good harvest data.

Seabirds and fish compete for food and in some instances juvenile salmon are used as food by seabirds. There is still little quantitative data on which to draw, however.

Endangered Species--Endangered species have been discussed in preceeding sections and included only those animals that spend at least a portion of their life cycle residing in the LNG marine route but did not include animals that occur only as passage migrants. Endangered species known to exist or believed to be present along the marine route are listed below and can or do occur generally throughout the route unless indicated otherwise:

Brown Pelican, Coastal zone of California
California Least Tern, Coastal zone of California
Southern Bald Eagle, South of latitude 40°N
Bowhead Whale, Alaskan waters
Blue Whale
Finback Whale
Gray Whale
Humpback Whale
Right Whale
Sei Whale
Sperm Whale
Short-tailed Albatross

Although it is not possible to delineate specific impacts on endangered species it is believed that impacts by moving LNG tankers will be negligible. Only a catastrophic explosion would impact any of these animals and the probability of an endangered species being in the impact zone is extremely low. In the case of a spill it is expected, as discussed in preceding sections, that most animals would escape unharmed.

Ecological Considerations

For the purpose of this description, it is entirely adequate to consider the Subarctic Pacific Region as an ecosystem. The region has the attributes ascribed to an ecosystem and it is the smallest unit to which we can address ourselves comprehensively for the purposes of discussion of this alternative.

The Subarctic Pacific Region is bounded on the northwest by the Japanese Islands and the coast of mainland Asia. The boundary on the northeast is the Pacific Coast of North America. The southern boundary is delineated by the 34°/oo isoheline which crosses the North Pacific on approximately the latitude of 42°N. The line is almost identical with the position at which evaporation equals precipitation. The above named conditions coupled with differential local heating have created distinctly different water structures north and south of 42°N (Dodimead, Favorite and Hirano, 1963).

Within the above region, the surface circulation is almost closed. It is a major gyre with five superimposed small gyres. Most of the circulation system features persist at deeper levels as well.

The species diversity for all major groups of animals has a decreasing south to north gradient. Among the better known are the six species of Pacific salmon which are endemic to the region. The sea otter is endemic, as is the red-legged kittiwake and Peale's peregrine falcon. Eighteen of 22 species of the family Alcidae occur here and many are endemic. Of the four remaining species, two are found just south of the region and only two, the razor-billed auk and the common puffin occur only outside of the North Pacific.

The entire biotic component within this ecosystem stands on a base of primary producers composed of green plants which utilize incoming solar energy, CO_2 and inorganic nutrients to synthesize organic matter. This is the first step in a complex flow of energy that is transferred step by step upward through a number of trophic levels. Seabirds, marine mammals and man are at the summit of the trophic hierarchy in a marine ecosystem.

The transfer of energy takes place over pathways known as food chains which are usually intertwined in complex food webs. If key nodes in these webs are removed a whole section of web may unravel.

Primary production and its relative values have been illustrated by example in the preceding section. Phytoplankton, attached algae and eelgrass are the principal primary producers in this ecosystem. Food chains are vulnerable at this level to disruption from pollution by foreign hydrocarbons, light reduction resulting from increased sediment loads and by abnormally depressed or elevated temperatures.

The herbivores occupying the next trophic level above the primary producers are the primary consumers. In a marine ecosystem zooplankton, intertidal and subtidal invertebrates and some fishes and birds are the main herbivores. Their numbers are inhibited by depressed populations of primary producers.

Food-chain concentrations of certain contaminants (biological magnification) has its beginning at the primary consumer level. Some ecosystem contaminants such as radioactive wastes and foreign hydrocarbons but collected and retained by the consumer that ingests them and undergoes further concentration as it moves upward through the food chain. The diagram of the numbers of organisms at each trophic layer below a sea lion in its food chain would look like a pyramid with the lone sea lion at the topmost point. In a simple case, a contaminant accumulated by each of several millions of phytoplanton is passed upward to a lesser numbers of herbivores, from which it goes to the next layer of even fewer primary carnivores, then to the layer containing a relatively small number of fish and ultimately to a single sea lion. For each million phytoplankton assimilated a molecule each of a particular hydrocarbon contaminant, say DDE, the sea lion could end up with a million molecules of DDE in its tissues. It is this sort of chain reaction which is blamed for the reproductive failure and, therefore, the endangered status of brown pelicans and peregrine falcons.

There may be one or several successive carnivore levels in a food chain. Several life forms may occupy a particular trophic level in a food chain or one organism may move between trophic levels. The more diversity there is in either direction in a food chain the more stable it will tend to be. An example of a trophic level which lacked diversity and, therefore, proved to be vulnerable can be found in the food chain of guano birds depended on the abundance of one fish, the anchovy. Historically, bird numbers fluctuated with no problem. Man entered the picture in direct competition with the birds. Modern technology made it possible for man to harvest the anchovy beyond its capacity to maintain its population. Now man has moved on but the drastically reduced anchovy population and bird population appear to be left at levels from which they cannot recover.

Food chains are the likely point of impact of ecosystem abnormalities but other vulnerable points also exist. For example, intertidal organisms, organisms adapted to remaining in place while the tide is out, can survive the periodic exposure they undergo when the tide is out. However, they are stressed by this exposure. A stressed organism is more susceptible to damage than an unstressed one. Elevated or depressed seawater temperatures are examples of abnormal conditions which could cause extra stress on organisms already stressed by a natural occurrence.

The Point Conception Terminal and the Pipeline from Point Conception to Cajon and Arvin, California

The final portion of the alternative delivery system consists of a receiving terminal and regasification plant to be constructed at Point Conception, California. Twin 42-in pipelines will carry the gas 142 miles northeastward to Arvin where it will be split, part of it being directed 105 miles southeastward through a single 42-inch pipeline to Cahon from which it is to be distributed to Southern California users. The remainder of the gas at Arvin will be introduced into existing pipelines to move it eastward to distribution systems which ultimately serve consumers in the central and eastern states. This latter distribution will utilize existing facilities supplemented by 107 miles of new pipeline between Dimmit and Dumas, Texas and 431 miles of new line from Waha to Rufugio, Texas, plus three minor segments of pipeline (1.1 to 9.3 miles in length) and the construction or modification of compressor facilities.

The following section is based on the Federal Power Commission, 1975a.

Analyses of the environment and impacts is undertaken in two parts:

1) The terminal at Point Conception and the pipelines to Arvin and Cajon, California.

2) The distribution system from Arvin, California eastward.

Climate

It is necessary to give a detailed account of local climatic conditions and unique weather phenomena in order to determine structural design and construction techniques of the regasification plant facilities and the assessment of potential impacts of plant emissions on the local environment. Extremes of climate can adversely affect pipeline construction activities.

Regional Climatology--The climate of the southern California coast is dominated by the Pacific Ocean and nearby mountainous terrain.

The diurnal temperature change is generally small along the coast. Even when high temperatures occur, the relative humidity is generally low, so discomfort is unusual.

A notable difference in climatic and meteorological conditions north and east of Point Conception is due to the abrupt change in orientation of the coastline.

Strong winds are more common at Point Conception than in other coastal locations in California because of its relatively unprotected position.

Foggy conditions occur during all parts of the year, but are most prevalent during the summer months. Details of the local climate pertinent to the terminal and gas transmission pipeline are discussed in the following sections.

Temperature--The coast of southern California experiences a relatively uniform annual temperature distribution due to the moderating influence of the Pacific Ocean.

The interior region of California where the terminus of the proposed pipeline would be located experiences a large diurnal and annual temperature distribution, due to the largely reduced maritime influence.

The table below summarizes temperature data for Lompoc, 13 miles north of Point Conception and for Bakersfield, approximately 20 miles northwest of Arvin Station. Temperature data from these two locations should be quite similar to that at the proposed site near Point Conception, and at Arvin, respectively, where the first pipeline segment would terminate.

Mean Temperature Data for Lompoc and Bakersfield, Calif., °F

Lompoc

	Mean Maximum	Mean Minimum
Summer	69.3	49.5
Winter	68.2	41.5
Annual	68.7	45.5

Bakersfield

	Mean Maximum	Mean Minimum
Summer	89.4	60.8
Winter	65.8	43.1
Annual	77.7	52.1

Precipitation--Precipitation in this area occurs mainly during the winter months because the semipermanent Eastern Pacific highpressure system weakens at this time, allowing the intrusion of low pressure systems into the area. Annual precipitation dramatically decreases from the coast to interior locations. Thunderstorms do not occur often near the coast, but showers and thunderstorms are observed over the coastal ranges sometimes during the summer when moist air from the south and southeast rises and becomes convectively unstable. Table 8.2.1.-22, which summarizes precipitation data for 1973, shows that very little rain falls during the summer months (April through September) especially in the interior sections of California such as Bakersfield. It is expected that the precipitation data for Lompoc would be similar to Point Conception and the data for Bakersfield would be typical of that along the proposed route.

Wind--Table 8.2.1-23 indicates the annual percentage frequency of wind speed by direction. This data indicates that the greatest frequency and the highest average wind speed are from the northwest. Winds greater than 29 miles/hour occur only 3.4% of the time.

Although not documented, local experience in the Point Conception area indicates that quite frequently, strong north to northwest winds occur, especially during mid-day. These winds may vary significantly with location along the coast and are generally stronger at the base of canyons than elsewhere (U.S. Coast Guard, 1974).

Table 8.2.1-22 Mean seasonal and annual precipitation data for Lompoc and Bakersfield, Calif., 1973

Lompoc

	Inches
Summer	2.10
Winter	11.10
Annual	13.20

Bakersfield

	Inches
Summer	1.21
Winter	4.51
Annual	5.72

Source: Federal Power Commission, 1975, Vol. III

Table 8.2.1-23 Percent frequency of wind speed by direction, Point Conception

ANNUAL

	Wind Speed (MPH)										
Wind Direction	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-40	40	Total	Mean Speed
N	2.0	2.8	3.8	2.7	2.1	1.9	0.4	0.5	0.2	9.5	13.4
NE	1.8	1.4	0.4	0.4	0.2	0.2	*	*	*	4.3	8.3
E	1.4	1.0	0.4	0.2	0.2	0.1	*	*	*	3.0	8.6
SE	0.9	1.2	0.4	0.4	0.2	0.2	*	*	*	4.0	10.5
S	1.2	1.6	0.6	0.4	0.4	0.2	*	*	*	5.0	8.7
SW	1.4	2.8	2.5	1.8	1.4	0.2	*	*	*	13.1	12.6
W	2.6	6.2	4.4	3.2	2.4	0.8	0.2	0.2	*	22.1	11.9
NW	2.4	5.5	7.0	5.6	5.4	3.2	0.7	0.7	0.3	32.6	17.0
VAR	*	*	*	0.0	0.0	0.0	0.0	0.0	0.0	*	3.3
CALM	6.2									6.2	0.0
											12.6
TOTAL	20.0	23.6	20.4	14.7	11.2	6.7	1.4	1.5	0.5	100.0	
CUMULATIVE	20.0	43.6	64.0	78.7	89.9	96.6	98.0	99.5	100.0		

Source: Federal Power Commission, 1975, Vol. III

Although tropical storms are very infrequent in this section of the country, strong winds can be associated with frontal passages and with transient pressure disturbances due to the influence of the semipermanent Eastern Pacific high pressure system. The extreme winds expected at Point Conception at various recurrence intervals are given in Table 8.2.1.-24. The time values refer to the expected duration of the average sustained wind for that time interval. These values have been interpolated from observations taken over land.

Temperature Inversions and Atmospheric Stability--When the temperature of the atmosphere increases with height, the dispersion rate of the atmosphere diminishes, resulting in the buildup of pollutants. Pasquill atmospheric classifications "E" and "F," which represent slightly stable and moderately stable atmospheric conditions, respectively, occur about 30 percent of the time at Vandenberg Air Force Base, which is about 15 miles north of Point Conception. Pasquill's stability categories were derived using the Turner method (Turner, 1964). The stability classifications give an objective estimate of air stability near the ground as a function of cloud cover, insolation, and wind speed.

The following data for seasonal and annual stability classes, as measured at Vandenberg Air Force Base, indicate that Category "D" is the predominate stability with a percent frequency of occurrence of nearly 50 percent:

Pasquill Classification	Percent Frequency of Occurrence		
	Summer	Winter	Annual
A (Extremely Unstable)	1.47	0.19	0.77
B (Moderately Unstable)	10.41	4.94	7.03
C (Slightly Unstable)	12.01	11.92	12.07
D (Neutral)	62.28	36.79	49.79
E (Slightly Stable)	3.36	16.00	9.85
F (Moderately Stable)	10.45	30.15	20.49

Source: United States Air Force, 1974.

It is expected that category "D" would also be the most predominant air stability at Point Conception.

Fog and Visibility--Cloudy days are generally associated with frontal passages during the winter months and with stratus clouds and fog which occur over land frequently during the summer. These phenomena are usually confined to late evening and morning hours, but they frequently persist over the nearshore waters throughout the day. These conditions frequently restrict visibility and, as Table 8.2.1.-25 indicates, they occur more frequently during the months of July, August, September, and October.

Topography

The proposed liquefaction plant and the first 5 miles of the proposed pipeline would be located 40 to 80 feet above the ocean on a gently sloping coastal terrace which is generally less than a mile wide. East-west trending coastal cliffs truncate the terrace 80 feet above a narrow beach. Approximately 4 miles north of the site the crest of the Santa Ynez Mountains parallels the coastline at elevations of up to 1,800 feet.

Table 8.2.1-24 Extreme winds, Point Conception

Recurring Interval	Maximum Instantaneous Gust	1 Minute	1 Hour	3 Hours	6 Hours
2 yr.	39	30	23	21	20
10	65	50	39	35	33
25	72	55	42	38	36
50	85	65	51	46	43
100	98	75	59	53	50

Wind speeds are given in miles per hour.

Source: Federal Power Commission, 1975, Vol. III

Table 8.2.1-25 Percent frequency of occurrence of reduced visibility

	½ Mile	1 Mile	5 Miles	# of Observations
Month	0.5	0.9	6.6	1,733
January	2.6	4.0	12.4	2,094
February	1.4	2.2	11.3	2,435
March	2.3	4.0	18.7	2,444
April	1.9	4.0	16.2	2,502
May	1.5	3.5	15.8	2,589
June	2.8	5.5	26.7	2,539
July	3.0	5.8	27.6	2,238
August	4.6	7.0	22.8	2,267
September	5.0	8.6	27.9	2,366
October	3.3	4.6	14.9	2,284
November	1.5	2.7	9.8	1,615
December	2.6	4.5	18.1	27,106

Source: Federal Power Commission, 1975, Vol. III

From the proposed LNG terminal site near Point Conception the associated pipeline route passes through five physiographic provinces. It originates in the Transverse Ranges and crosses the southern Coast Ranges, the southern San Joaquin Valley, the southernmost Sierra Nevada, and the western Mojave Desert. These provinces span most of the geomorphic features which can be found in California.

To about MP 25 the proposed route would cross the trend of the Transverse Ranges. Mountains and major drainages trend east-west. With the exception of the segment along the floor of Drum Canyon the proposed route follows ridge crests within the Santa Ynez Mountains, Santa Rosa and Santa Rita Hills. The only major drainage crossed is the Santa Ynez River.

As the proposed route crosses the Los Alamos Valley at MP 25 it enters the southern Coast Ranges. Here the structure trends northwest. The rolling gentle topography of the Los Alamos Valley, Solomon Hills, and Santa Maria Valley contrast with the slopes just traversed and the rugged terrain which awaits at the head of Tepusquet Canyon. Once again the route follows ridge crests through the Sierra Madre Mountains and the Caliente Range to where it enters the Carrizo Plain at MP 68. The major drainages crossed are San Antonio Creek and the Sisquoc and Cuyama Rivers.

The northerly sloping coalescent alluvial fans of the Carrizo Plain support the route at an elevation of about 2,100 feet. Several intermittent streams but no major drainages are crossed before it enters the Elkhorn Hills at MP 86.

A pass in the hills allows the route to enter the Elkhorn Plain which is a smaller feature parallel to the Carrizo Plain. The route parallels the axis of the plain to its southwestern terminus where at MP 94 it enters the Temblor Range.

The easterly orientation of the route brings it into the San Joaquin Valley at MP 101 about 2.5 miles southeast of Maricopa. The rather moderate topography of the Temblor Range represents the last hilly terrain to be crossed by the Point Conception to Arvin Station pipeline until it enters the Tehachapi Mountains for the last 5 miles.

Within the southernmost edge of the San Joaquin Valley, the alignment remains on the broad alluvial fans which slope northward toward the center of the valley. The average elevation of this section is about 800 feet although the range in elevation is about 700 feet. With the exception of the Santa Ynez River and the Sisquoc River all the streams which are crossed are intermittent.

At MP 137 the route enters the Tejon Hills just north of the Comanche Point Oil Field. It then heads due north across ridges to Comanche Creek, follows the east side of the canyon and arrives at Arvin Station 2 miles northeast of Comanche Spring.

The Arvin to Cajon section of the proposed route would be an additional 109 miles commencing at MP 133.1 of the Point Conception to Arvin Station segment. From its starting point to MP 31, the proposed route crosses the western foothills, the high interior mountain valley, and the eastern foothills of the Tehachapi Mountains from which it emerges onto the western slopes of the Mojave Desert. Within 10 miles the alignment climbs from an elevation of 800 feet to the 4,000-foot plateau occupied by Cummings Valley. As the route continues to the east, it traverses the southern border of Tehachapi Valley at about the 4,400-foot contour and crosses the 5,000-foot crest of the eastern Tehachapis near Oak Creek Pass. It enters the Mojave

Desert adjacent to Oak Creek Road, west of the town of Mojave, 5 miles from and 1,400 feet lower than the Tehachapi Mountain Crest.

Throughout the desert, the proposed pipeline remains on broad alluvial fans and dry lake beds. Only in the Bissell Hills, near Adobe Mountain and in the Shadow Mountains is the topography significantly different and then only briefly. Due south of the town of Mojave, at about MP 40, the route changes from east to southeast maintaining this heading for 50 miles through Antelope Valley. The elevation on this stretch ranges from 2,500 to 3,200 feet.

At MP 90, the route heads due south for the last 19 miles. To MP 104 it climbs 1,100 feet up the broad alluvial fan extending north from Baldy Mesa. From MP 104, the alignment extends into the San Bernardino Mountains, crosses the ridge at Cajon Summit (elevation 4,400 feet) and descends to a terminus in Crowder Canyon 1.5 miles west of Summit.

Table 8.2.1.-26 summarizes the topography in terms of the overall relief, and the average and maximum slope along the route. In addition, the maximum slope adjacent to the route is included. In mountainous regions the average slope adjacent to the route is similar to the maximum slope along it.

Geology

Structure--This discussion of the geologic environment begins with a description of the structure beneath and adjacent to the proposed LNG terminal. A brief sequential description of the structure beneath the proposed pipeline alignment follows, and the general stratigraphy is described in the same sequence. The seismicity and other geologic hazards of the region are subsequently described.

The proposed terminal site is located on the southern slope of the Santa Ynez Mountains, the westernmost of the Transverse Ranges. Structurally, this slope is a southward dipping homocline. Offshore from the site the structure is modified by folding and faulting.

The site is located on the southward dipping northern limb of a syncline whose axis comes ashore less than 1,000 feet west of the site. Underneath the surficial terrace deposits the shales of the Sisquoc Formation dip 35° to 45° to the south. The closest mapped onshore fault is the northern branch of the Santa Ynez fault zone (including the Pacific and Bulito faults) which is about 3.5 miles north of the site.

Offshore the subsurface is complicated by numerous folds and faults. The south branch of the Santa Ynez fault passes within 2 miles of the end of the proposed trestle - 3 miles from the site. This and the northern branch of the Santa Ynez fault are the dominant structural elements in the immediate site area. Several faults have been mapped closer to the site including a possible offshoot of the Santa Ynez less than 4,500 feet from the end of the proposed trestle.

The proposed pipeline route parallels the strike of the homoclinal structure along the coastal terrace to Drake and then proceeds north across it into the mountains. Three to 4 miles inland the structure is interrupted by an extensive zone of faulting including the Bulito, Pacifico and Santa Ynez faults. This is at about MP 8 of the proposed route and from here to the Santa Ynez river (MP 16), the structure consists of numerous east-west trending folds.

Table 8.2.1-26 Topography of proposed pipeline route

Region	Mileposts	Slope (feet per mile) Along Route Maximum	Slope (feet per mile) Along Route Average	Slope (feet per mile) Adjacent Maximum	Relief (feet)
Point Conception-Arvin					
Transverse Ranges					
Coastal Terrace	0-5	500	100	*	40
Santa Ynez Mtns. and Santa Rosa Hills	5-16	2,000	1,000	5,500	1,600
Santa Rita Hills	16-18	1,800	1,000	3,300	600
Drum Canyon	18-22	270	130	3,300	600
Purisima Hills	22-25	2,000	600	3,300	950
Southern Coast Ranges					
Los Alamos and Santa Maria Valleys, Solomon Hills	25-35	1,600	600	4,400	870
Tepusquet Creek Valley	35-39	600	200	4,400	400
San Rafael Mtns, and Caliente Range	39-68	3,200	1,000	5,500	2,300
Carrizo Plain	68-86	400	40	*	220
Elkhorn Hills and Plain	86-94	300	40	1,500	200
Temblor Range	94-101	1,250	500	2,200	1,800
San Joaquin Valley	101-137	160	40	*	700
Sierra Nevada					
Tehachapi Mtns.	137-142	2,000	1,000	2,400	500
Arvin-Cajon					
Sierra Nevada					
Tehachapi Mtns.	0-31	3,000	100	4,500	3,600
Mojave Desert					
Fremont Valley and Antelope Valley	31-104	300	50	*	1,600
San Bernadino Mtns.	104-109	1,900	200	2,400	460

* Generally does not exceed maximum slope along alignment.

Source: **Federal Power Commission, 1975, Vol. III**

Upon exiting the Transverse Ranges, the alignment enters the southern portion of the Coast Ranges. This northwesterly trending region is some 400 miles long and 50 miles wide and is structurally comprised of northwest trending strike-slip faults and more westerly trending anticlines and synclines.

While no faults are observed at the surface in the Los Alamos Valley and the Solomon Hills (MP 24-33), wells have revealed several faults of mid-Pleistocene age. It is possible that the Los Alamos earthquakes of 1920 and 1915 were due to activity on a fault near the southern border of the valley.

In the Sierra Madre Mountains between MP 37 and MP 58 the proposed route crosses at least 10 known faults. Folds in this region are generally asymmetric with the steeper limbs on the southwest and axes which plunge southeast.

The LaPanza and Caliente Ranges are formed on anticlinal structures related to westward thrusting on east-dipping thrust faults. These mountains form the southwestern border of the Carrizo Plain and host the proposed alignment from about MP 58 to MP 68.

The structural depression of the Carrizo Plain is bordered on the northeast by the San Andreas fault zone. At about MP 86, the alignment crosses the Elkhorn Scarp of this zone and enters the Temblor Range.

Near Maricopa the proposed route enters the San Joaquin Valley. This structural basin has received sediments continuously since the early Tertiary Period. Its southern margin contains a number of active faults including the White Wolf fault, which the proposed pipeline would cross, and the Pleito thrust fault.

As the route crosses Comanche Point, the westernmost extension of the Tehachapi Mountains, it crosses a series of apparently inactive en echelon faults. A few miles farther away the proposed pipelines would terminate at Arvin Station approximately 1 mile south of the White Wolf fault.

The Arvin to Cajon route begins within the Tehachapi Mountains. Although these mountains are topographically continuous with the main body of the Sierra Nevada to the north, they are structurally different. With the northwestern and southeastern boundaries sharply defined by faults they resemble a horst, an elevated block between two normal faults. But it appears that neither of the bounding faults are of this type.

The interior structure of the Tehachapi Mountains is dominated by northwest trending faults and a broad syncline occupied by the Tehachapi Valley. The southeastern boundary of the mountains is structurally located at the Garlock fault--a major active fault exhibiting considerable left-lateral movement. The fault is about 250 miles long.

At MP 31 the proposed route leaves the Tehachapis and enters the Mojave Desert. The western end of this alluviated plain is bordered on the south by the San Andreas fault and the veneer of unconsolidated sediments covers the erosional surface comprising the base of most of the area. Numerous small sedimentary basins exist and commonly contain dry lake beds. The crystalline basement rocks do appear on the surface in and adjacent to isolated ranges within the plain and the route crosses about 12 miles of this granitic material.

Tertiary formations within the desert are deformed by eastward trending folds and right-lateral northwest trending faults. Ongoing studies by the

U.S. Geological Survey indicate that deformation associated with these features is continuing.

The last 1 or 2 miles of the route are within the Transverse Ranges. Here the structure is dominated by the San Andreas fault zone which passes approximately 3.5 miles south of the terminus of the proposed pipeline.

Stratigraphy--Submarine surficial deposits are relatively thin and discontinuous in the vicinity of the proposed marine trestle. Except for a possible buried stream channel where thicknesses reach 20 feet, the fine, well-sorted quartz sand is seldom more than a few feet thick. The nature of this material including its composition, sorting, and grain size imply a northern upcoast source. Apparently very little of the surficial sediment is derived locally and it has been estimated that approximately 100,000 cubic yards of sediment are transported south around Point Conception in a year.

The marine trestle would be underlain by upper Miocene silt-clay and mud-stones probably of the Sisquoc Formation. This formation also forms the bedrock beneath the proposed LNG vaporization plant. The Sisquoc Formation underneath the on-land facilities consists of highly fractured diatomaceous marine mudstone which is often unstable on steep slopes. This problem could be compounded by the steep southerly (downslope) dip of the strata. The formation extends to depths in excess of 2,000 feet beneath the site. Above the bedrock are Pleistocene terrace deposits which consist of unconsolidated gravel, sand, silt, and clay. Their thickness ranges from 2 to 30 feet and they are easily eroded.

With the exception of the first 5 miles, most of the initial 60 miles of proposed route is nearly perpendicular to the regional strike. Tertiary and Holocene sediments dominate the indurated deposits although sediments as old as the Jurassic Period occur along the route. Most of the proposed pipeline would pass through unconsolidated Holocene deposits composed mainly of fanglomerate and alluvium.

Holocene alluvium consists of generally fine-grained material with local lenses of gravel and occasional boulders. The deposits are irregular in thickness and in plan ranging up to perhaps 50 feet in thickness. These stream deposits and the coarser colluvium, which commonly covers adjacent slopes, are found in stream valleys and on terraces. Erosion of these unconsolidated materials is severe on steep slopes although on gentler slopes the problem is not as great.

The proposed route lies on unconsolidated deposits as listed below (areas less than 0.5-mile long are not included):

Point Conception to Arvin: Mileposts 0-5.5, 8-8.5, 15-15.5, 16.3-22, 24-39.5, 100-137

Arvin to Cajon: Mileposts 0-8, 11-15.3, 16-25.6, 28-47.2, 49.2-65.5, 73.2-82, 84.5-108.9

Along the coastal terrace the proposed route encounters Miocene and Pliocene shales and mudstones of the Sisquoc and Monterey Formations. The former is a highly fractured diatomaceous marine mudstone while the latter also includes thin-bedded siliceous, marine shale, minor quantities of limestone, and bentonite in the lower beds. The Monterey beds are also generally fractured and commonly contain tar. Both of these formations are reasonably resistant to erosion but they present stability problems on slopes because they are so highly fractured.

In the Transverse Ranges the route crosses: (1) shales and claystones, (2) sandstones, (3) volcanics, and (4) unconsolidated sediments. The rocks range in age from the Cretaceous to the Holocene Periods. Shales crossed by the alignment belong to the Espada, Jalama, Anita, Cozy Dell, Rincon, Monterey, Sisquoc and Foxen Formations. These shales are generally not resistant to erosion as evidenced by their occurrence in topographic lows. While steep slopes and even cliffs may be encountered in the Monterey and Sisquoc Formations, they are not stable as previously noted.

The Rincon Formation presents special problems. It is comprised of highly fractured claystones which "tend to weather rapidly and deeply, and develop thick, unstable, expansive soils. The Rincon Formation erodes to low, rounded hills with hummocky, highly unstable, landslide-prone slopes. In addition, the upper part of this formation contains bentonite beds that are extremely unstable." (Dames and Moore, 1974) This formation is crossed at MP 55 and it probably underlies the landslide deposits and most of the alignment from MP 14 to MP 15.

The sandstones beneath the proposed route belong to the Matiliza, Sacate, Gaviota, Alegria, Sespe and Vaqueros Formations. In this region sandstones are more resistant to weathering than shales, especially when the sands are as well-indurated as most of those crossed by this alignment.

The Tranquillon Formation, consisting of rhyolite, agglomerate, and ash, is the only volcanic unit exposed in this region. It lies unconformably above the Rincon Formation and has undoubtedly contributed to the instability of the terrain near MP 15 since it too contains bentonite.

Unconsolidated gravels, sands, silts, and clays are found within the following formations in addition to alluvium and terrace deposits: Careaga, Paso Robles and Orcutt. These upper Pliocene and Pleistocene formations, as well as the Quaternary deposits, are easily eroded.

Within the Coast Ranges Province, the route traverses the most varied stratigraphy along the proposed route. The age of the exposed units ranges from the Jurassic Period to the present, and the units display a complete modal range of clastic sediments, as well as igneous and metamorphic rocks.

From MP 25 to MP 40 the route passes through unconsolidated materials belonging to the formations noted for the Transverse Ranges and, in addition, the Morales Formation.

Shales belonging to unnamed deposits of Eocene or upper Cretaceous age (Dames and Moore, 1974), are crossed, and those belonging to the Morales and Monterey Formations may be crossed, within the Coast Ranges.

Sandstone exposures are quite extensive in this region and may be assigned to the Jurassic Knoxville Formation, the Jurassic to Cretaceous Franciscan Formation, undifferentiated Cretaceous deposits, and Tertiary formations including the Pattiway, Simmler, Sespe, Vaqueros, Branch Canyon, Santa Margarita, and Morales Formations. Queries indicate formations which may not be crossed.

The Franciscan Formation contains substantial amounts of volcanics and altered intrusives. These materials present slope and foundation stability problems due to the presence of the mineral serpentine which has low shear strength.

In the Temblor Range (MP 94-100) the pipeline might encounter portions of the Temblor, Santa Margarita, Monterey, Jacalitos and Etchegoin

Formations. These are well to loosely consolidated siliceous and diatomaceous shales, sands, and conglomerates.

Across the southern San Joaquin Valley, the proposed route crosses only Holocene alluvium and Pliocene coarse clastic sediments. The latter occur adjacent to the Tehachapi Mountains beyond MP 134 and include portions of the Santa Margarita, Walker, Vaqueros, Temblor, Chanac, Tacalitos, Etchegoin, Tulare, Meganos, Tejon and Kern River Formations.

The Arvin to Cajon pipeline, as proposed, would cross the Tehachapi Mountains and the Mojave Desert. In the Tehachapi Mountains of the Sierra Nevada Province, the route crosses pre-Tertiary metamorphics, Mesozoic intrusives, Tertiary volcanics and sediments and unconsolidated materials deposited from late in the Tertiary Period to the present.

The metamorphics include gneiss, schist, quartzite and marble. Of these materials, schist and minor amounts of marble are the only ones crossed by the proposed alignment (Dames and Moore, 1975).

Although the intrusives probably underlie most of the first 30 miles of this route, they are only exposed from MP 5 to MP 11 and from MP 25 to MP 28. There are two main rock types: a hornblende quartz diorite and a quartz monzonite. Apparently only minor, isolated areas of volcanics, mainly felsite plugs and dikes, are exposed within the proposed alignment.

Sandstones of the Whitnet, San Lorenzo, Vaqueros, Santa Margarita, and Horned Toad Formations as well as shales from the latter four units and the pyroclastic deposits of the Kinnick Formation comprise the Tertiary section. Apparently only the Whitnet and possibly the Kinnick Formation would be crossed by the proposed route.

Unconsolidated and poorly consolidated deposits of Tertiary and Recent age include the Bena Gravel and the Chanac and Tehachapi Formations as well as fanglomerate, alluvium and terrace deposits. These unconsolidated deposits are generally comprised of sand or coarser material derived from the adjacent hills.

Within the Mojave Desert, rock types are similar to those found in the Tehachapi Mountains. However, the metamorphics are probably older, pre-Mesozoic, and the unconsolidated materials are generally younger, being no older than Quaternary.

Near MP 87, the route crosses portions of the metamorphosed Oro Grande Formation which consists of thick carbonates, quartzites, schists and hornfels. They are very resistant to weathering and form prominent bluffs and hills.

In the following sections: MP 47-53, 66-74, and 84-86, the pipeline would encounter Mesozoic intrusive rocks. These are mainly hornblende diorite, quartz monzonite and granite and are resistant to weathering. While Tertiary sediments and volcanics of the Gem Hill and Bissell Formations occur in the area the route is not known to cross them.

Eighty-three (83) percent of the total Arvin to Cajon route and about 61 percent of that portion within the Mojave Desert would be across unconsolidated deposits. In the desert, these include fluvial, aeolian (wind transported) and lacustrine (lakebed) deposits.

The wind deposited materials consist of loose, fine-grained sand and cover extensive areas near MP 80 and MP 90. The lake deposits consist of extremely fine-grained clays representing (now dried) lakebeds. These clays probably extend considerable distances beyond the present boundaries of the lakes or playas and would probably be encountered during excavation of the alignment.

The last mile or two of the proposed route falls within the Transverse Ranges. Unconsolidated and weakly consolidated materials are all that would be crossed in this region. These deposits are alluvium, fanglomerate and stream terrace sediments of Quaternary and Holocene age and are similar to those found in the province previously described. The Crowder Formation of Tertiary age is weakly consolidated fluviatile material which is also found within the last mile of proposed route.

Seismicity--It is now widely accepted that the overall seismicity of the earth is a result of the relative motion of distinct crustal plates. Continents and ocean floors comprise different plates and it is through earthquakes that the interaction of these masses is made manifest.

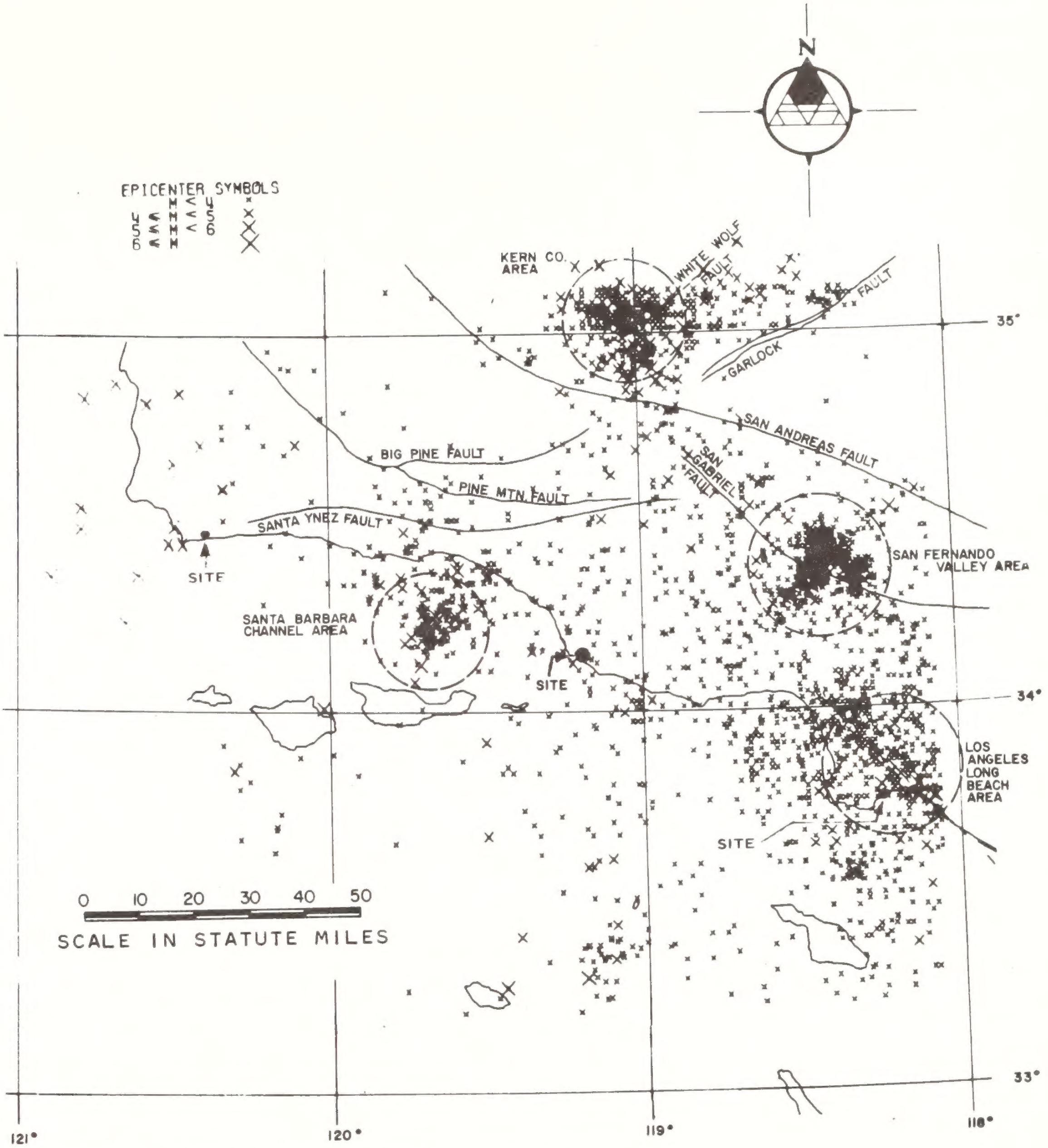
The plate which contains the North American continent meets the Pacific plate along the San Andreas fault in California. The relative motion along this fault is right-lateral with the land southwest of the fault moving northwest with respect to the adjacent continent. The stress at this boundary and its precursors has produced the physical structures which make up the physiographic provinces of southern California. The bend in the coastline which is included in the Transverse Ranges province has been a focus of tectonic activity since the middle of the Tertiary Period. Here the northern component of force has uplifted the ranges on extensive east-west folds and faults releasing in vertical motion the stress which could not be released horizontally along the San Andreas, Garlock, and subsidiary faults. This vertical uplift is still taking place.

More ancient plate interactions with a roughly east-west orientation are the probable cause of the northerly trend of the Sierra Nevada, Coast, and Peninsular Ranges.

There are three major orientations and two major types of faults in southern California. An east-west orientation predominates on reverse faults while strike-slip faults trend northeast-southwest or northwest-southeast. Right-lateral motion is predominant on faults with the latter orientation such as the San Andreas, whereas the other orientation is generally associated with left-lateral motion as along the Garlock fault.

To determine the hazards associated with faulting and earthquakes, it is necessary to have a reasonable record of previous activity in the area of interest. Unfortunately, the historical record for faults that are considered active is poor to non-existent. The most extensive historical record of activity along a fault in North America is represented by the San Andreas fault, where records span a period of roughly 120 years. However, it can be shown that this fault has been active for at least 25 million years so that the historical record covers less than one ten-thousandth of one percent of the lifetime of this feature. Knowledge of earthquake activity in southern California extends back no further than 1769 and Richter and Gutenberg (1954) note that "even a major earthquake could have escaped notice until about 1887" due to low population density and the lack of instrumentation. The same authors note that the record for earthquakes of magnitude 8 and over is not complete until after 1904 with 1932 marking the first date from which the record may be assumed complete to magnitude 3 in southern California. (See Figure 8.2.1-25.)

In spite of the problems the State of California has the best statistical base for extrapolation to large magnitudes and several workers



Source: Federal Power Commission, 1975, Vol. III

Figure 8.2.1-25 Earthquake epicenters for the period 1934-1969 west of 120°21' West longitude and 1932-1972 elsewhere

have produced tables or relations expressing the expected mean return rate for earthquakes of various magnitudes.

Expected Mean Return Rate for Earthquakes

Magnitude	Mean Return Period (years)
6	1.4
7	8.7
8	56

Existing tabulations vary by a factor of two in return period for a magnitude 8 earthquake since there have been so few events of this size within the state. Moreover, this table may be applied to southern California alone since the majority of California earthquakes have occurred there. Others give a value of 71 years for magnitude 8 in southern California--not significantly different from the above value. While these numbers cannot be used in a strictly predictive sense, they can be used to infer the probability of a given event during a design period. If the 71-year figure is adopted, there is a 63 percent probability that at least one magnitude 8 earthquake will occur during a design period of 71 years and a 76 percent chance of the same event in 100 years. It has been about 70 years since the last event of such magnitude in California and about 118 years since the last known event of that size in southern California. On this basis, the probability of no event within the next 30 years is only 12 percent for southern California. It has been proposed that a 100-year recurrence interval for the southern section of the San Andreas fault, so the probability that the proposed site will be subjected to a magnitude 8 earthquake on the San Andreas fault within the next 30 years is nearly 80 percent.

Table 8.2.1-27 contains all of the active or potentially active onshore faults which have been mapped and which could significantly affect the proposed project. Any fault which has been determined to have moved during the Quaternary Period is considered potentially active. In some cases the extensions of these faults are also considered potentially active even if they have no demonstrated Quaternary activity. Given in the table are the fault name, the maximum possible earthquake magnitude as determined by total fault length, the maximum probable magnitude and an estimate of the maximum bedrock acceleration, and surface displacement at the nearest part of the proposed facilities. The maximum possible earthquake values are taken from a least squares curve. It should be noted that since this is a "best fit" and not a bounding curve, larger magnitude earthquakes have been associated with shorter faults than are implied by the curve.

In order for the maximum possible event to take place movement would have to occur along the entire length of the fault. This is not generally the case. Therefore, maximum probable earthquake has been set assuming that only 25 percent of the fault would be involved. This decreases the magnitude by 0.9 units. While this procedure is somewhat arbitrary, it should be noted that most damaging earthquakes of magnitude greater than 5.5 have been accompanied by movement on at least 33 percent of the fault with which they were associated. The U.S. Geological Survey, suggests that a magnitude 7.5 earthquake be taken as the maximum credible event for the Santa Barbara Channel region.

Using map distances and the attenuation curves the maximum accelerations from the credible events have been estimated for the proposed site and pipeline. The near-fault acceleration values given in Table 2 in the report by Page, et al. (1972) compare favorably with the accelerations listed above. It should be emphasized that the accelerations listed for

Table 8.2.1-27 Active or potentially active faults

Fault	Minimum Length (miles)	Maximum possible magnitude	Maximum probable magnitude	Maximum acceleration(g) at		Maximum displacement if greater than one foot	
				Site	Pipeline		
Point Conception-Arvin alignment							
Santa Ynez (S)	90	8.2	7.3	0.7+	0.7+	-	(0)
Santa Ynez (N)	"	"	"	"	0.7+	6	(3)
Nacimiento	185	8.6	7.7	0.2	0.7+	10	(5)
Big Pine	95	8.2	7.3	0.14	0.7+	6	(1)
Rinconada	185	8.6	7.7	0.15	0.7+	10	(1)
South Cuyama	45	7.7	6.8	-	0.7+	3	(1)
La Panza	43	7.7	6.8	-	0.7+	3	(2)
San Juan	40	7.6	6.7	-	0.7+	3	(2)
Morales	32	7.5	6.6	-	0.7+	2.5	(1)
San Andreas	750	9.1	8.2	0.1	0.7+	20	(1)
Pleito	27	7.4	6.5	-	0.66	-	(0)
White Wolf	53	7.8	7.8*	-	0.7+	10	(2)
Arvin to Cajon alignment							
White Wolf	53	7.8	7.8*		0.55	2	(0)
Springs	7	6.5	5.6		0.43	-	(3)
Garlock	250	8.8	7.9		0.7+	10	(2)
Willow Springs-Rosamond	15	7.0	6.1		0.45	-	(0)
Mirage Valley	22	7.3	6.4		0.6+	2	(1)
Blake Ranch	17	7.1	6.2		0.35	-	(0)
Helendale	55	7.8	6.9		0.27	-	(0)
San Andreas	750	9.1	8.2		0.67	4	(0)

* Probable=possible here because the 1952 event was of this magnitude.

Parentheses enclose the number of mapped fractures which would be crossed.

Source: Federal Power Commission, 1975, Vol. III

facilities within the fault zones are in fact taken from an abscissa representing a distance of 2 miles from the site. These entries indicate a minimum value (+) and not a specific value since no data exists to allow extrapolation to locations within a fault zone.

Soils

Within the boundaries of the proposed site, there are 12 mapped soil units representing nine soil series. These series are listed in Table 8.2.1.-28. In general, the soils at the site may be characterized as shaley, granular loams and they are mainly derived from the underlying shales of the Sisquoc Formation or from the topographically higher Monterey Formation.

The only soil which differs markedly from this description is the Montezuma clay which is found on the southwestern corner of the terrace adjacent to the Canada del Cojo. This clay is expansive and lies immediately southwest of the proposed location for the seawater LNG vaporizers.

Most of the proposed terminal facilities would be located on soils of the Watsonville Series. These have claypan sub-soils that rest upon the unconsolidated marine deposits of the coastal terrace. The surface soil is dark gray, hard, medium acid sandy loam to loam, very friable to friable when moist, and weakly granular. It puddles easily if disturbed when too wet. The subsoil is dark gray to dark grayish-brown, very hard, medium acid compact clay. The upper subsoil is distinctly prismatic, and the lower part tends to be blocky. The parent material is gray, hard, massive, medium acid sandy clay loam to sandy clay. The natural vegetation is annual grasses and herbs, with some brush along the terrace escarpment (Cole, et al., 1958). The vegetation on these soils is used for rangeland in the area of the proposed terminal.

The soils which would be crossed by the proposed pipeline may be placed into three categories:

I. Soils of the alluvial fans, floodplains, valleys and terraces.

II. Soils of the uplands and high terraces, and low hills within the Mojave Desert.

III. Soils of the basins and alkali flats.

Soils in Category I are nearly level to moderately steep loamy sands to clay loams where they mantle sedimentary rocks. Somewhat gentler slopes are developed on granitic rocks and the soils in these regions are coarser ranging from sand to sandy loam. Category II is typified by gently sloping to very steep relief and sand to clay loam or silty clay soils. Nearly level, fine sand to silty clay loam or clay loam soils comprise Category III.

The corrosivity of Category III soils ranges from moderate to high. In addition, the Pond-Tray-Oban soils of this category which occupy the central portion of the Mojave Desert near Rogers Dry Lake and El Mirage Dry Lake have high shrink-swell potential.

Upland soils of the Mojave Desert are of low to moderate corrosivity and shrink-swell potential. This is generally true for the other soils of Category II, however Shedd-Santa Lucia-Diablo soils and Los Osos soils are highly corrosive.

Table 8.2.1-28 Soil units within the proposed Point Conception LNG terminal site

Soil Series	Percent of Site (approx)	Soil Type	Subsoil Type	Drainage Internal	Drainage Runoff	Erosion Hazard
Watsonville	26	Loam	Same	Slow	Very slow	Moderate
	3	Dark gray, hard, granular loam	Same	Very slow	Slow to medium	Severe
Watsonville (undifferentiated)	10	Dark gray, hard granular soils, variable texture	Same	Very slow	Rapid	Severe
Arguello	25	Dark gray shaly loam, granular	Dark gray, sub-angular blocky shaly clay loam	Medium	Slow	Slight
Jalama	10	Dark gray shaly sandy loam, granular	Dark-grayish brown, blocky shaly clay loam hard pan	Medium	Slow to medium	Slight to moderate
Terrace breaks	10	Miscellaneous soil on high slopes		-	-	Severe
Elder	5	Shaly clay loam	Same	Medium	Slow	Slight
Coastal Beach	5	--------------Sandy-----------		-------------Variable-------------		
Santa Lucia	3	Dark gray granular stony soils, variable texture	Same	Medium	Rapid to very rapid	Severe
	1	Dark gray shaly clay loam, granular	Lighter and increasingly shaly with depth	Medium	Slow to medium	Moderate
Montezuma	1	Clay (adobe)	Same	Slow	Slow	Slight
Cayucos	1	Dark-gray, blocky shaly soil	Dark gray, shaly, blocky clay	Slow	Rapid to very rapid	Severe

Source: Federal Power Commission, 1975, Vol. III

Category I soils are generally of low corrosivity. Their shrink-swell potential may range up to moderate.

Most of the soils of Category II have a potential for severe wind or water erosion. This is due to the relative steepness of the slopes, the thin soil profile and/or the loose granular nature of the soil. In hilly areas the soil is seldom greater than 4 feet in depth.

Soils of Category I may be severely eroded during the infrequent periods of high rainfall which are typical of southern California. Category III soils are generally safe from water erosion due to the low relief of their surroundings, although the potential for wind erosion may be severe.

Hydrology

Regasification Plant Site--The proposed site is in a coastal drainage region which lies between the approximately east-west oriented Santa Ynez Mountains and the Santa Barbara Channel coastline. The coastline parallels the mountains at the proposed site location. The crests of the mountains near the proposed project site are inland approximately 3 miles and range in elevation from 1,000 to 1,600 feet. Drainage areas are typically perpendicular to the coastline and range from 0.5 to 3 square miles. As a result of the steep slope and the unfavorable water retention characteristics within the watershed, stream channels are deeply incised and runoff is rapid.

The two largest streams in the site area are Canada del Cojo and Barranca Honda. Several springs exist in the drainages of these streams and contribute to streamflow.

The climate is maritime and rainfall occurs principally during the winter. Annual precipitation averages range from 16 inches near the coast to 30 inches near the mountain crest.

Surface Water Hydrology--The Canada del Cojo is associated with a drainage basin of approximately 3.2 square miles. The main stem of the stream has a length of 4 miles and an average gradient of 300 feet per mile. Within the site property the stream has steep banks up to 40 feet high. Approximately 0.5 mile upstream from the coast the Canada del Cojo is joined by a major tributary, the Canada del Cementerio.

The Barranca Honda drains an area of approximately 2 square miles. The stream is joined by a parallel flowing tributary (Canada del Gato) approximately 0.1 mile upstream from the coast. The main stem is 2.3 miles long and has an average gradient of 325 feet per mile. The area between the Canada del Cojo and Barranca Honda drains through several gullies. No perennial flow is found in the gullies.

Runoff from the drainages occurring on the site goes directly into the Santa Barbara Channel. Because of their lack of importance to the water resources of California, these streams are not gauged, and the runoff is not known. Table 8.2.1.-29, however, indicates the relationship between mean annual rainfall and runoff for Santa Barbara County. Equations derived from local area coastal drainages for calculating peak streamflows were applied by the applicant to the Canada del Cojo and Barranca Honda. The results of these calculations are shown in Table 8.2.1.-30.

During periods of high flows streams may be expected to scour several feet into their beds because the steep slopes of the stream channels

Table 8.2.1-29 Mean annual rainfall-runoff relation for Santa Barbara county

Precipitation (inches)	Runoff (inches)	Precipitation (inches)	Runoff (inches)
14	0.20	26	2.95
15	.30	27	3.30
16	.45	28	3.70
17	.60	29	4.10
18	.75	30	4.60
19	.95	31	5.15
20	1.15	32	5.75
21	1.40	33	6.35
22	1.65	34	7.05
23	1.95	35	7.75
24	2.25	36	8.50
25	2.60		

Source: Federal Power Commission, 1975, Vol. III

Table 8.2.1-30 Calculated peak streamflow

Drainage Basin Name	Area in Square Miles	Recurrance Interval Years	Calculated Peak Flow cfs
Canada del Cojo	3.16	2	111
	3.16	5	378
	3.16	10	670
	3.16	25	1,183
	3.16	50	1,672
	3.16	100	2,247
Barranca Honda	1.99	2	81
	1.99	5	276
	1.99	10	494
	1.99	25	879
	1.99	50	1,248
	1.99	100	1,686

Source: Federal Power Commission, 1975, Vol. III

produces high water velocities. A depth of scour in the stream bottom equal to difference in depth between the flood flow and the normal flow is not uncommon.

Groundwater--Principal regional water-bearing formations in the rock units are the Monterey shale and the Vaqueros sandstone.

Groundwater occurs in the fractures of the siliceous Monterey shale. Water obtained from the few wells in this formation has produced small quantities of mineralized water for livestock use. Although no known wells exist locally in the Vaqueros Formation, the presence of springs indicates that the formation is a freshwater aquifer.

Groundwater quality is inferred from the fact that some springs in the area are used for domestic and livestock purposes. This would suggest that the water probably contains dissolved solids not exceeding 2,000 mg/l.

Pipeline Routes--

General--The water resources associated with the proposed pipeline route is divided into 11 drainage regions (Figures 8.2.1.-26 and 27). They are (from Point Conception to Cajon Pass):

1) Coastal Drainage Region
2) Santa Ynez River Drainage
3) San Antonio Creek Drainage
4) Sisquoc River Drainage
5) Cuyama River Drainage
6) San Juan Creek Drainage
7) Soda Lake Drainage
8) San Joaquin Valley Drainage
9) Antelope Valley Drainage
10) Mojave River Drainage
11) Santa Ana River Drainage

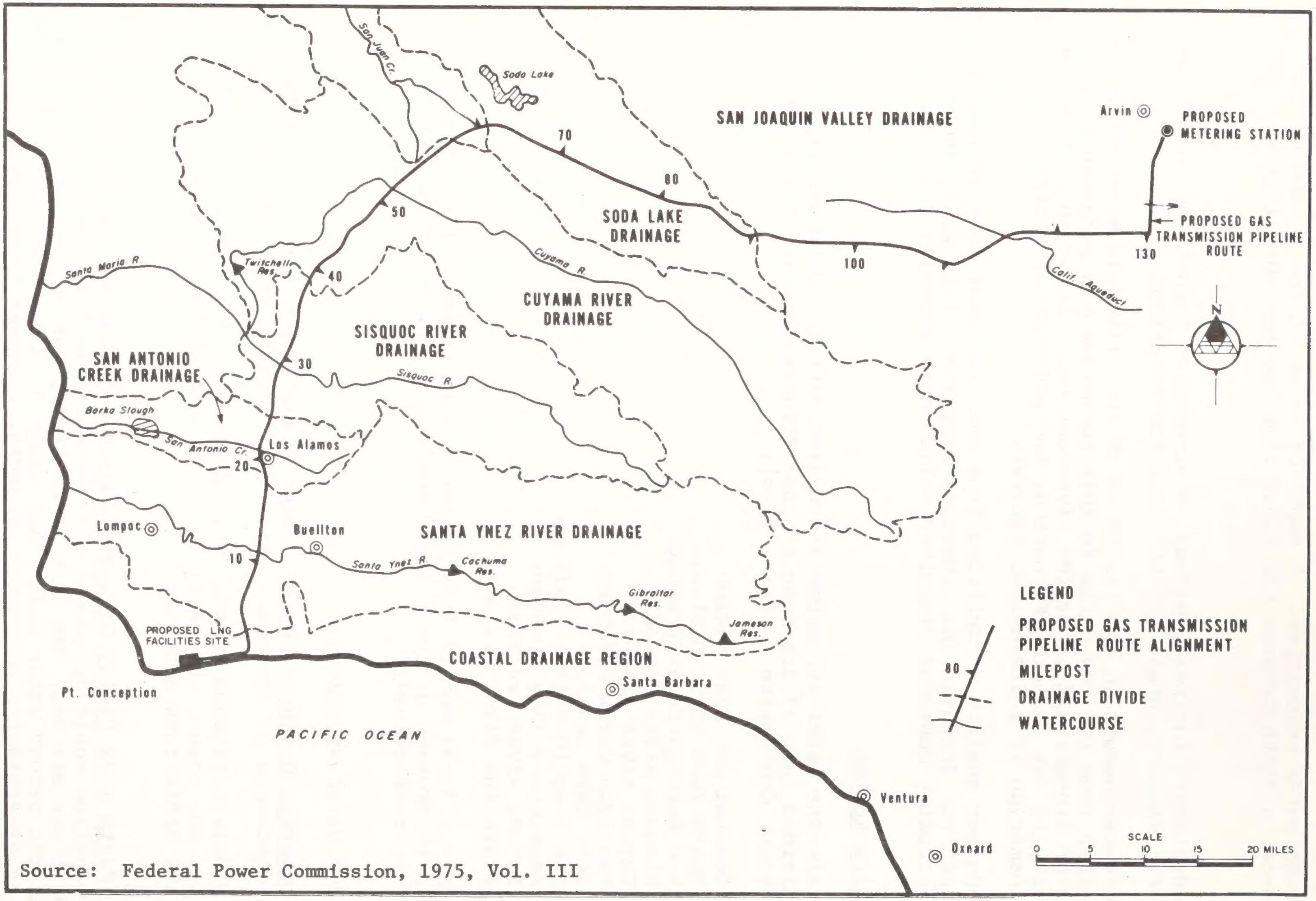
Tables 8.2.1.-31 and 32 list drainage basin information for streams which would be crossed by the Point Conception to Arvin and the Arvin to Cajon routes, respectively.

Surface Water Hydrology--

1. Coastal Drainage Region. Significant aspects of this drainage have been discussed in connection with the proposed regasification terminal.

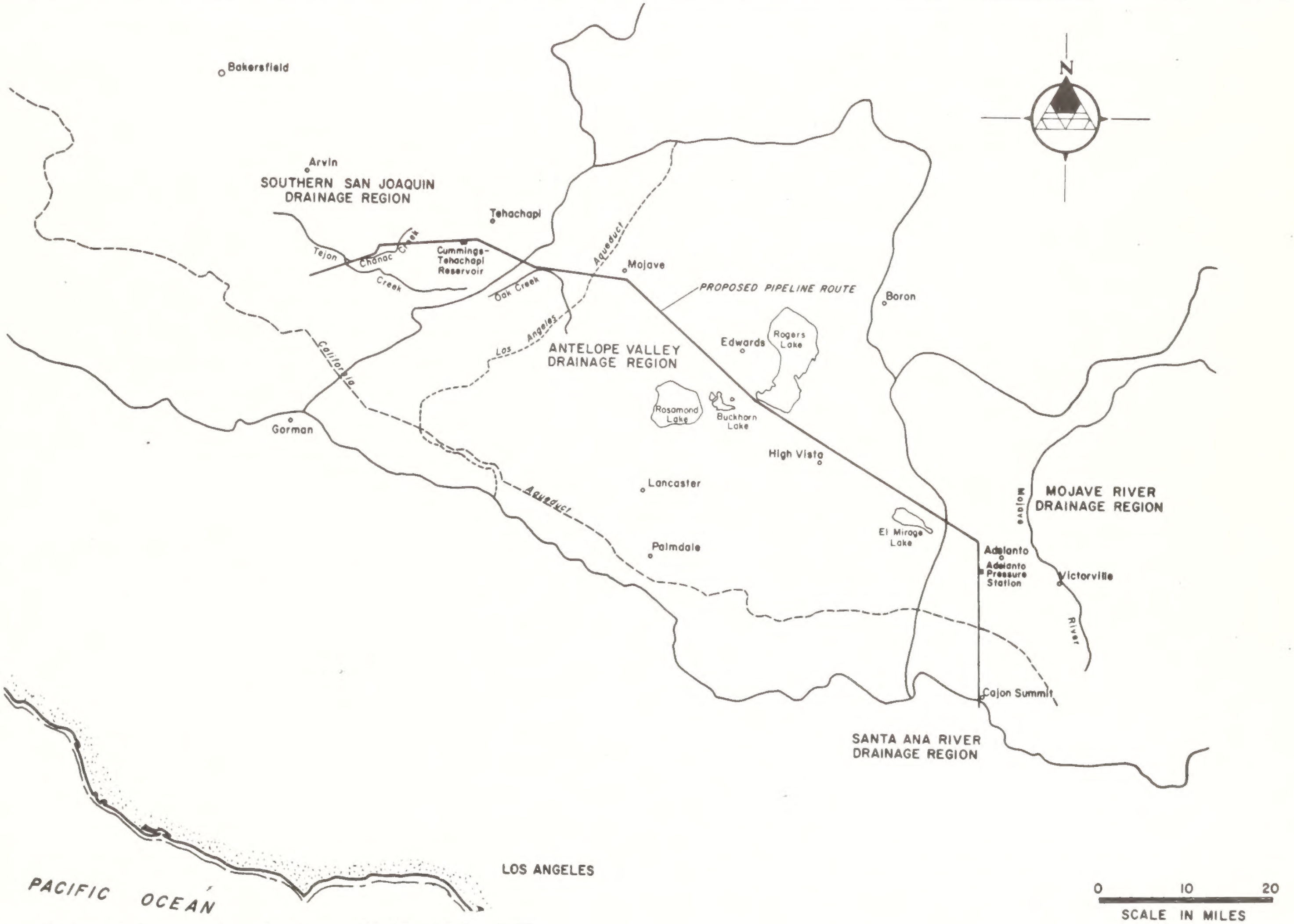
The pipeline extends through this region for 7.2 miles. The first 4.7 miles follow the coast, the remainder runs in a northerly direction to the crest of the Santa Ynez Mountains.

2. Santa Ynez Valley Drainage Region. Approximately 16 miles of the proposed pipeline would cross seven tributaries in this drainage. The largest of these streams, the Santa Ynez River, has an average flow of 40 cubic feet per second (cfs) and a flow range of from 0 to 81,000 cfs. Three U.S. Bureau of Reclamation storage projects, upstream of the proposed Santa Ynez River crossing, store water for irrigation and municipal use for the Santa Barbara area.



Source: Federal Power Commission, 1975, Vol. III

Figure 8.2.1-26 Drainage regions - Point Conception to Arvin pipeline route



Source: Federal Power Commission, 1975, Vol. III

Figure 8.2.1-27 Drainage regions - Arvin to Cajon pipeline route

Table 8.2.1-31 Drainage basin information

Drainage Basin Name	Approx. Total Area (square miles)	Approx. Area Above Alignment (square miles)	Milepost at Crossing	Design Storm: 6-hour 50-year (inches)	Approx. Maximum Elev. (feet)	Elev. at Crossing	Historical Flood on Mainstem	
							Date	Discharge in cfs
COASTAL DRAINAGES								
Canada del Cojo	3	3	0	5.5	1600	80		
Barranca Honda	2	1.95	0.3	5.5	1750	35		
Canada de la Llequa	1	0.95	0.9	5.5	1720	35		
Arroyo San Augustin	2	1.98	1.8	5.5	1685	80		
Canada de la Agujas	1	0.90	2.6	5.5	1685	75		
Arroyo El Bulito	2	1.98	3.0	5.5	1450	35		
Canada de las Panochas	1	1	4.2	5.5	1328	35		
Canada del Agua	1	1	4.3	5.5	1341	35		
Canada de Santa Anita	3	3	4.6	5.5	1200	40		
Canada del Coyote	0.5	0.5	Does Not Cross	5.5	1035	Does Not Cross		
Canada del Sacate	2	2	Does Not Cross	5.5	1300	Does Not Cross		
SANTA YNEZ RIVER DRAINAGE								
Gaviolito Creek	1	0.50	7.5	3.5	1360	950		
El Jaro Creek	53	13	8.1	3.5	2000	720		
Atascoso Creek	1	0.80	8.3	3.5	1050	780		
Alamo Creek	2	2	Does Not Cross	3.5	1280	Does Not Cross		
Ytias Creek	5	0.50	11.3	3.5	1760	Does Not Cross		
Canada de la Vina	2	0.20	Does Not Cross	3.5	1680	Does Not Cross		
Santa Ynez River	950	650	15.4	3.5	6800	240	1/25/69	81,000
Santa Rosa Creek	10	9	18.4	3.5	1600	520		
SAN ANTONIO CREEK DRAINAGE								
Unnamed Stream	1	0.70	24.2	3.3	1672	700		
Canada de las Calaveras	1	1	Does Not Cross	3.3	1600	Does Not Cross		
San Antonio Creek	150	60	25.4	3.3	2000	520	2/25/69	2,300
Howard Canyon	3	2	26.6	3.3	1600	720		
SISQUOC RIVER DRAINAGE								
Unnamed Tributary to Cat Canyon	0.5	0.25	29.6	3.5	1450	800		
Cat Canyon	18	7.20	30.1	3.5	2000	710		
Long Canyon	1	0.30	31.3	3.5	1120	780		
Olivera Canyon	1	0.80	33.0	3.5	1050	550		
Sisquoc River	475	430	33.7	3.5	6800	450	12/6/66	23,200
Tepusquet Creek	30	27	35.4	3.5	2500	640		
Colson Canyon	10	10	38.6	3.5	3100	894		
CUYAMA RIVER DRAINAGE								
Buckhorn Canyon	8	8	43.9	4.0	2700	980		
Miranda Pine Canyon	20	19	45.5	4.0	4100	940		
Aliso Creek	10	5	47.7	4.0	3400	1140		
Clear Creek	5	2	54.1	4.0	3300	1580		
Cuyama River	1200	800	55.3	4.0	7500	1310	2/25/69	17,800
Gypsum Canyon	2	1.50	56.6	4.0	3500	1580		
Sycamore Creek	3	0.10	Does Not Cross	4.0	3050	Does Not Cross		

Source: Federal Power Commission, 1975, Vol. III

Table 8.2.1-32 Drainage basin characteristics

DRAINAGE BASIN NAME	APPROXIMATE AREA ABOVE ROUTE (SQUARE MILES)	MILEPOST AT CROSSING	DESIGN STORM: 6-HOUR 50-YEAR[1] (INCHES)	APPROXIMATE MAXIMUM DRAINAGE BASIN ELEVATION (FEET)	APPROXIMATE ELEVATION AT PROPOSED CROSSING (FEET)
TEJON CREEK	50	4.1	3.00	7981	1340
CHANAC CREEK	47	8.4	2.50	5700	2325
CHANAC CREEK	39	10.9	2.50	5700	3735
BRITE CREEK	7	17.6	2.50	7100	4280
WATER CANYON	6	19.4	2.50	7800	4350
ANTELOPE CANYON	4	22.3	2.50	7800	4360
BLACKBURN CREEK	6	24.3	2.50	7600	4420
MENDIBURN CREEK	2	24.9	2.50	6400	4460
UNNAMED DRAINAGE	1	25.4	2.25	5400	4430
OAK CREEK	30	DOES NOT CROSS	2.50	7981	DOES NOT CROSS
MANZANITA WASH	2.6	102.5	1.80	4650	3710
UNNAMED WASH #1	2.2	103.9	1.80	4625	3830
UNNAMED WASH #2	1.5	104.6	1.50	4603	3900
ORO GRANDE WASH	0.2	106.8	1.50	4449	4120

Source: Federal Power Commission, 1975, Vol. III

The principal source of groundwater in this drainage region is the alluvium associated with the Santa Ynez River. Water withdrawn from this alluvium is used for irrigation and municipal purposes.

3. San Antonio Creek Drainage Region. Approximately 6 miles of the proposed pipeline would cross three tributaries of San Antonio Creek in this drainage. The most important of these tributaries flows in Howard Canyon and drains 2 square miles. The average flow rate at the proposed pipeline crossing is 1.1 cfs. During periods of high runoff (flows of 2,300 cfs have been recorded) large silt loads are possible.

Groundwater occurs in the fractures of consolidated rocks, in the Paso Robles Formation and in river alluvium. The alluvium provides water for livestock watering, irrigation in Los Alamos Valley, and the town of Los Alamos municipal water supply.

4. Sisquoc Drainage Region. This region would be crossed by approximately 14 miles of the proposed pipeline. The major stream to be crossed in this drainage, the Sisquoc River, has an average discharge of 43.2 cfs and flow occurs all year.

Groundwater is available from the fractures of consolidated rocks and from valley floor alluvium. Water from these groundwater sources is used for irrigation and domestic purposes. Downstream of the proposed crossing, surface water is also used for irrigation purposes.

5. Cuyama Drainage Region. Much of this drainage region lies in the Los Padres National Forest. The Cuyama River and six of its tributaries having drainages ranging from 2 to 20 square miles would be crossed by 15 miles of the proposed pipeline.

The Cuyama River, which flows intermittently, has an average discharge of 23.7 cfs near the proposed crossing and a peak recorded flow of 17,800 cfs. Fifteen miles downstream of the Cuyama River crossing the river flows into the Twitchell Reservoir. The Cuyama River carries considerable silt even during periods of low flow.

Groundwater is available from the fractures of consolidated rocks and from thick alluvium deposits along the Cuyama River. Alluvium groundwater is used for irrigation, and springs and wells in the higher areas underlain by consolidated rock provide all the water needed by isolated ranches.

6. San Juan Creek Drainage Region. Four miles of the proposed pipeline would cross this drainage. The only stream of significance, San Juan Creek, flows only after there has been substantial rainfall.

Groundwater which supplies some small-capacity wells at the higher elevations occurs in the fractures of consolidated rocks. Downstream, particularly in the Salinas Valley, both groundwater and surface water are used for irrigation, municipal and industrial purposes.

7. Soda Lake Drainage Region and San Joaquin Valley Drainage Region West of Arvin. No information is currently available.

8. Southern San Joaquin Drainage Region. Approximately 25 miles of the proposed pipeline from Arvin to Cajon would cross two intermittent drainages in this region. Tejon Creek (MP 4.1) drains approximately 50 square miles of area above the pipeline crossing, Chanac Creek (MP 8.4) drains an area of approximately 47 square miles above the point where it is crossed.

There are no data on streamflow or flooding from Tejon or Chanac Creeks. However, the creeks drain areas that receive relatively little precipitation; consequently, they produce little runoff. Flash floods could occur with high intensity storms and could produce severe scouring in flow restricting canyons.

Between MP 17.6 and 25.4 the route crosses six intermittent creeks that drain areas that range from 1 to 7 square miles. One of these streams, crossed at MP 24.3 in Blackburn Canyon, has significant scour potential during periods of high runoff.

The only major water storage facility in the region is the Cummings-Tehachapi County Water District Reservoir between MP 16.2 and 16.5.

Groundwater occurs primarily in unconsolidated alluvial deposits with the majority of pumpage being from the valley floor. This groundwater is used primarily for agricultural and domestic uses.

9. Antelope Valley Drainage Region. This region is traversed by 60 miles of the proposed pipeline. No major drainages are crossed. The Los Angeles Aqueduct which is discussed later would probably be crossed aboveground.

Between MP 57 and 63 the route passes between Rogers and Buckhorn Dry Lakes. There is standing water on these lakes during periods of high winter runoff.

Usable groundwater in this region occurs in the younger and older alluvial deposits. The depth to the water table is highly variable. Most of the groundwater extracted in this region is used for agriculture.

10. Upper Mojave River Drainage Region. This region is crossed by 23.5 miles of the proposed pipeline. The California Aqueduct is crossed at MP 100, and four wide, deep stream channels are crossed beginning at MP 102.5. These channels have since been cut off from their source by the San Andreas fault zone, and carry only minor amounts of runoff.

11. Santa Ana River Drainage Region. The final 1.3 miles of the route descends Cajon summit into the Cajon Canyon drainage, which is a tributary to the Santa Ana River. No significant drainages are crossed in this region. Based on topographic sand/soil conditions, erosion potential is moderate.

Groundwater supplies are limited and due to the lack of land development along the route in this region, there is no groundwater use.

Physical Oceanography--

General--The site of the proposed marine terminal and vaporization plant lies on the northern end of the Southern California Bight, approximately 3.5 miles east of Point Conception in the area of the National Ocean Survey wave measurement Stations 5 and 6 (see Figure 8.2.1.-28). The Southern California Bight is an open embayment of the Pacific Ocean extending from Point Conception to Baja, California. The coastline in this area turns abruptly at Point Conception to an east-west orientation, forming the northern end of the Santa Barbara Channel. The Santa Barbara Channel is bounded on the south by a chain of islands approximately 30 miles from the mainland.

Tides--On the west coast, the astronomical tide is characterized as mixed semidiurnal. For a period of approximately 10 days, one tidal cycle (duration: 25 hrs.) has two high waters and two low waters. This is followed by a 3 to 4-day period during which the 25-hour long cycle is composed of only one high and low water.

Tide statistics for National Ocean Survey Stations 5 and 6 at Point Arguello and Gaviota, respectively, are presented in Table 8.2.1.-33.

Higher water levels than those produced by the astronomical tides acting alone can generally be expected as the result of onshore winds and/or low barometric pressure. However, sea level changes caused by seasonal weather patterns in this region are probably less than one-half foot.

Waves--Comparisons of sea and swell roses for wave Stations 5 and Station 6 reflect the effects of the protection from heavy northwest swells and rough sea conditions afforded the Santa Barbara Channel by the configuration of the mainland. The dominant direction of swell and sea approach at Station 5 is from the northwest whereas the dominant direction of swell at Station 6 is from the west. In response to prevailing winds, the dominant direction of sea approach at Station 6 is from the northwest. The dominant westerly swell at Station 6 is less than 5 feet high 78 percent of the time and the dominant northwest to west sea is less than 5 feet high about 85 percent of the time.

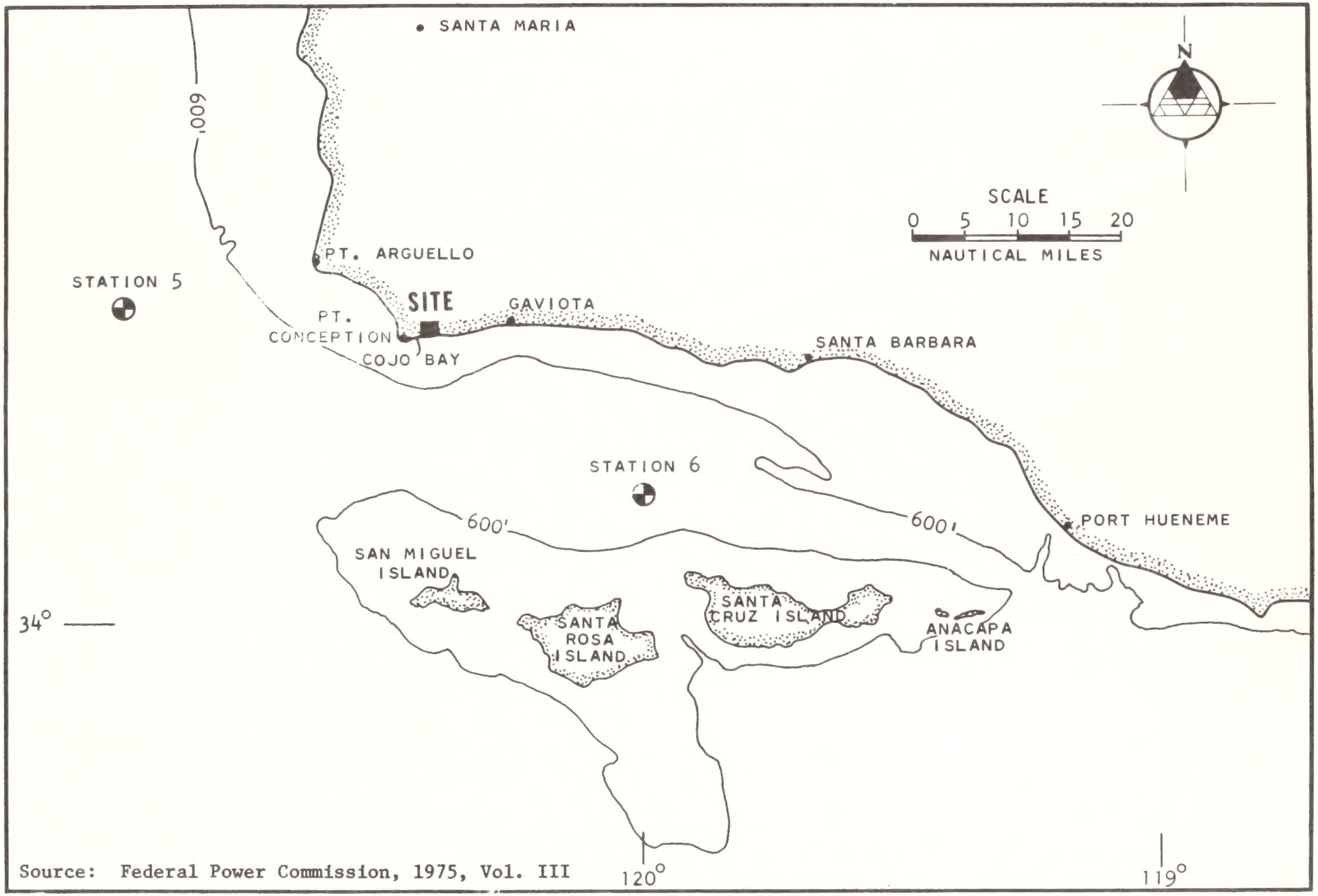
A severe storm study conducted by Oceanographic Services, Inc. (1971) of offshore Gaviota in the Santa Barbara Channel indicates that the predominant direction of wave approach in the shallow waters adjacent to the coast is from west to southwest. Table 8.2.1.-34 indicates some wave conditions observed during severe storms in this area.

Significant wave heights in Cojo Bay are 10 feet or less for about 95 percent of the year, and 9 feet or less for about 65 percent of the year.

Currents--A prime influence of the water movement offshore of the west coast is the California Current. This current transports approximately 42 million cubic feet per second of relatively cool, low-salinity water southward.

South of Point Conception, a large, counterclockwise gyre (circular motion) forms between the mainland and the California Current. The inshore side of this gyre, the Southern California Countercurrent (Figure 8.2.1.-29), transports relatively warm saline water northward through the Channel Islands. This northwesterly countercurrent off Point Conception is best developed in the period from November through January.

In the spring and early summer, strong northerly and northwesterly winds push the California Current offshore. This permits upwelling which supplies nutrient-rich water to the coastal waters.



Source: Federal Power Commission, 1975, Vol. III

Figure 8.2.1-28 Wave hindcast stations near Point Conception

Table 8.2.1-33 Astronomical tide data

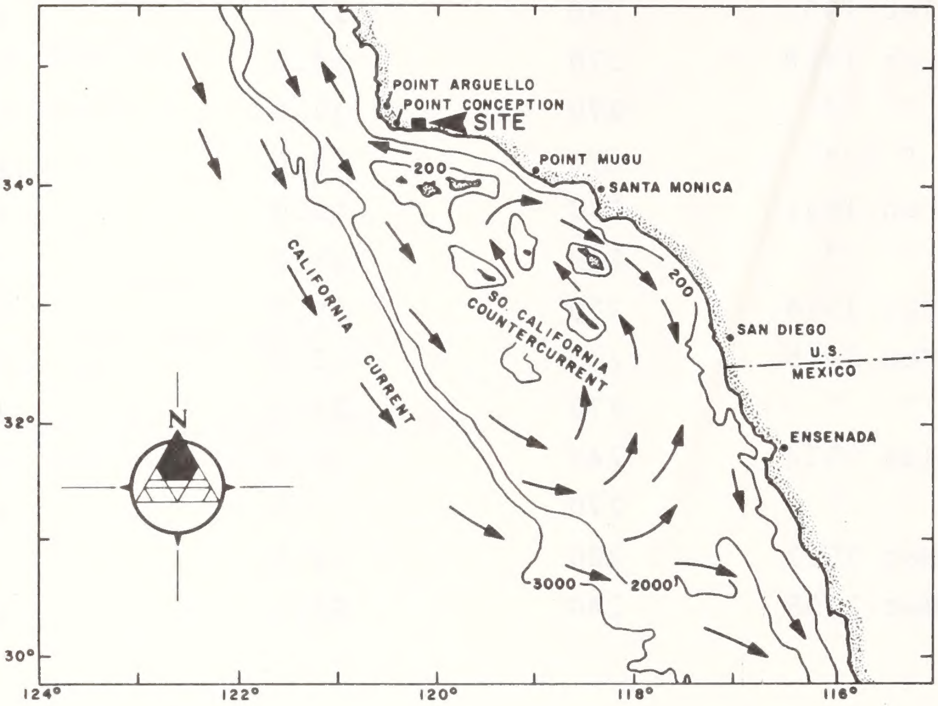
	Avila	Gaviota
Mean Higher High Water	5.2	5.3
Mean High Water	-	4.6
Mean Tide Level	2.7	2.8
Mean Sea Level	-	2.49
Mean Low Water	-	1.0
Mean Lower Low Water	0.0	0.0
Mean Range (Mean High Water - Mean Low Water)	3.5	3.6
Diurnal Range (Mean Higher High Water - Mean Lower Low Water)	5.2	5.3

Source: Federal Power Commission, 1975, Vol. III

Table 8.2.1-34 Severe storm wave data

	Date	Θ (degrees True)	H_s (significant height, feet)	T_s (period, sec)
Westerly	Feb 1963	215	20.0	13
	Feb 1959	240	13.5	12
	Apr 1958	270	14.5	11
	" "	270	17.0	15
	" "	270	18.0	15
	Feb 1941	270	12.0	10
	" "	240	17.0	9
	Dec 1916	270	15.0	12
	Feb 1915	240	18.5	10
	" "	270	14.0	11
	Jan 1914	245	15.5	13
	" "	270	12.0	11
	Mar 1912	220	11.0	9
	Mar 1905	240	20.5	14
Southeasterly	Feb 1963	110	10.0	8
	Feb 1959	110	16.0	8
	Feb 1941	110	17.0	8
	Dec 1927	120	17.0	9
	Feb 1915	135	13.5	9
	Jan 1914	135	10.0	8
	Mar 1905	110	18.0	9

Source: Federal Power Commission, 1975, Vol. III



ARROWS INDICATE APPROXIMATE DIRECTION OF FLOW

DEPTH SHOWN IN METERS

SCALE

0 100 200

KILOMETERS

Source: Federal Power Commission, 1975, Vol. III

Figure 8.2.1-29 Surface circulation (0-100m), Southern California bight

Speed of currents past Point Conception average 0.3 knots northerly flow from October through January.

The littoral transport of sediment in the nearshore zone is predominantly to the east throughout the year.

Tsunamis--Since 1946, tsunamis generated at distant locations have been recorded at several stations along the west coast. Major tsunami heights for several stations near the Santa Barbara Channel and Point Conception are presented in Table 8.2.1.-35.

Flood elevations with a frequency of once every 100 years and once every 500 years caused by tsunamis have been calculated for the Santa Barbara area to be 6.2 feet and 12.6 feet, respectively, above mean sea level. The foregoing data apply to the proposed marine terminal in that they provide an order of magnitude of possible tsunami occurrence and inundation in the region.

Temperature--Temperatures of the coastal waters in the northern part of the Santa Barbara Channel are influenced by the general circulation patterns of the different water masses in the region as well as by seasonal climatic changes, fluctuations in solar heating and nocturnal radiation, and the mixing effect of wind and waves.

The lowest annual surface water temperatures are the result of the offshore upwelling of deep, cold water. These temperatures occur during the months of February through May. Warmer climatic conditions and the strengthening Southern California Countercurrent produce the highest surface water temperatures from July through October.

Surface water temperatures measured in the surf zone between 1956 and 1968 at both Avila and Gaviota are given in Figure 8.2.1.-30. Seasonal variations in temperatures of the coastal water adjacent to the site, which are similar in magnitude to those recorded at Avila and Gaviota, can be expected. The coldest water temperatures are expected to occur during the months of January to May, with small vertical and horizontal temperature gradients. A thermocline structure can be expected during the warm months of July through October.

Transparency--The transparency (an indication of the ability of sunlight--required for photosynthesis--to penetrate the upper portion of the water column) of the nearshore waters in the vicinity is affected by wave action, runoff, currents, upwelling, and biological activity.

Mean transparencies of the coastal waters in the Southern California Bight ranged from less than 20 feet to greater than 60 feet during the late 1950's. Observed transparency values indicated a decreased clarity in more shallow waters.

Chemical Oceanography--

Salinity--Fluctuations in salinity along the inshore regions can result from regional circulation and mixing processes, upwelling of deep ocean waters, runoff from adjacent land, and precipitation and evaporation.

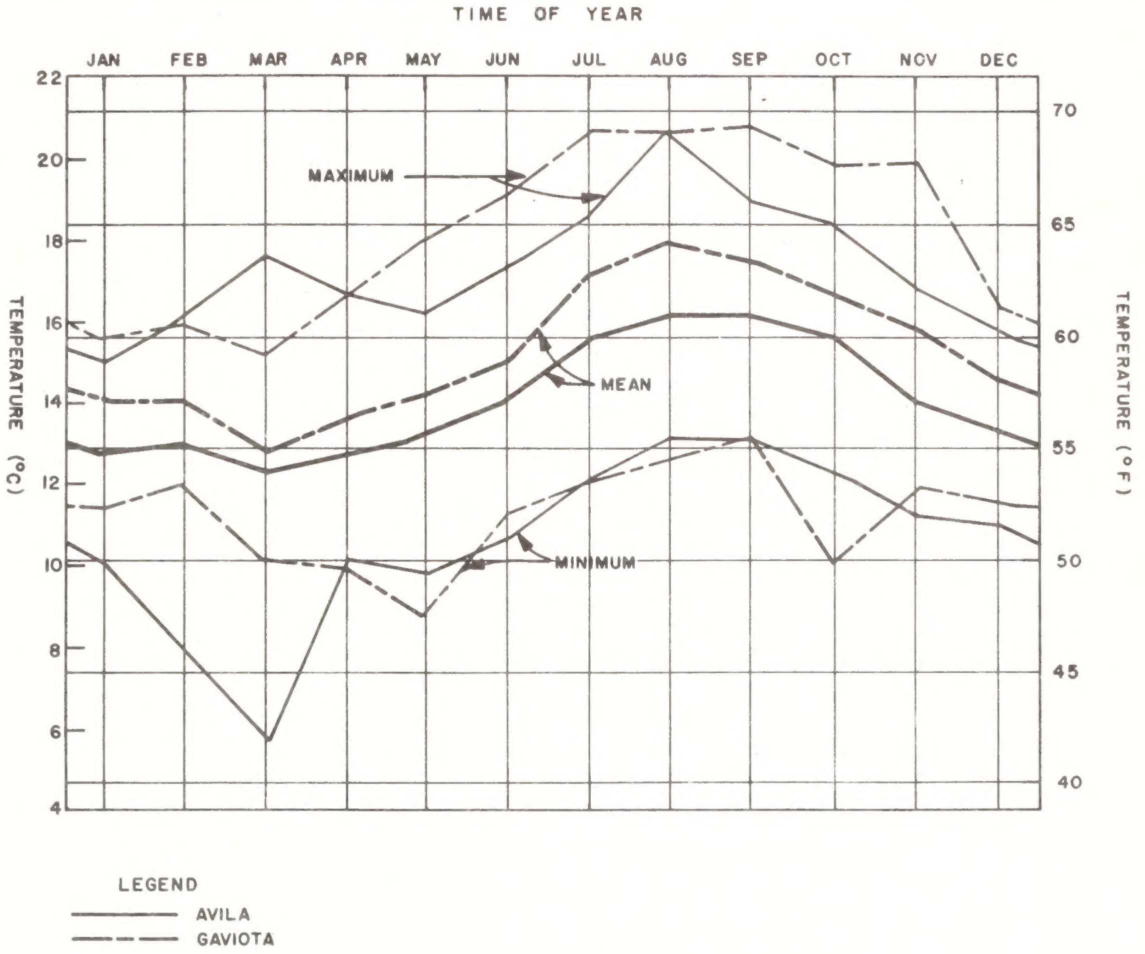
Salinity in the general vicinity of Point Conception decreases with increasing distance offshore, and increases with depth. Surface salinities

Table 8.2.1-35 Major tsunami heights at selected stations

Date of Earthquake	4-1-46	11-4-52	3-9-57	5-23-60	3-28-64
Location	Aleutians	Kamchatka	Aleutians	Chile	Alaska
Magnitude	7.4	8.3	8.0	8.5	8.4
Recording Station					
Avila Beach	8.5	9.5*	3.5	-0-	10.4*
Rincon Island					5.9*
Port Hueneme	5.5	4.7	3.5	8.8	-0-
Santa Monica	-0-	3.6	3.0	9.1	6.5

* Gauge limit exceeded

Source: Federal Power Commission, 1975, Vol. III



Source: Federal Power Commission, 1975, Vol. III

Figure 8.2.1-30 Surf temperature at Gaviota and Avila, 1956-1968

measured at Avila (Figure 8.2.1.-31) indicate the seasonal variation of salt concentration in nearshore waters. Salinity minima are typically recorded in winter when precipitation and runoff are low, and evaporation is high.

Dissolved Oxygen--Dissolved oxygen (DO) levels in the water column are influenced by 1) the oxygen mixing with open ocean water, 2) rates of diffusion across the air-water interface, 3) rates of oxygen consumption and production by living organisms, and 4) absorption and generation rates associated with other chemical reactions.

Surface DO concentrations between Point Conception and Santa Barbara (measured between 1957 and 1959) ranged from 3.8 to 15.2 milligrams per liter. The DO was found to be lowest in winter and highest in late spring and summer.

pH and Nutrients--An average pH of 8.2 was measured in coastal waters adjacent to the proposed plant site from 1957 to 1959.

Concentrations of the nutrient elements nitrogen, phosphorus, and silicon are closely linked to biological productivity in the marine environment. In the upper layers of the water column, where the penetration of light is good and biological activity is high, nutrient concentrations are almost continually being diminished.

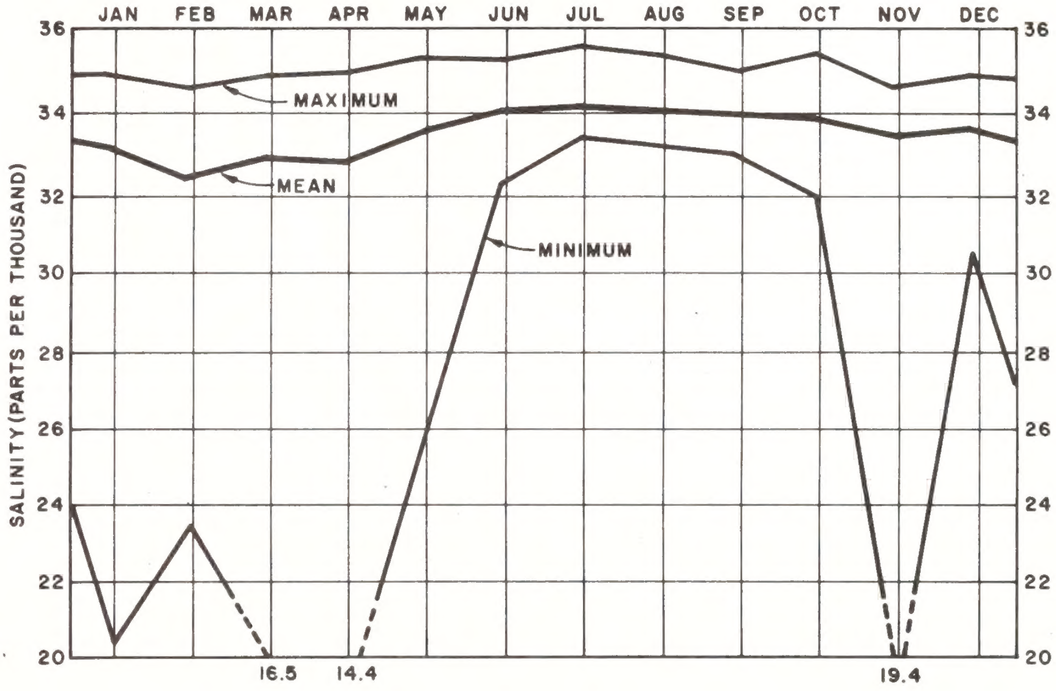
Nitrogen, phosphorus and silicon were all observed to be in greatest abundance in the surface coastal water in the Point Conception region between April and June. This is attributed to upwelling.

Vegetation

Regasification Plant Site--Five different vegetational communities (coastal strand, coastal bluff, coastal sage scrub, herbland, and riparian woodland) occur on the proposed LNG plant site and associated beach area. (A sixth community, oak woodland, occurs off the site.) It can be seen in this figure that the various communities often overlap forming assemblages with components from two or more communities. Around 75 percent of the site is vegetated with herbland, with most of the remaining vegetation coastal sage scrub and riparian woodland.

The coastal strand or beach community is restricted near the site because the beach is narrow and often waveswept at high tide. However, wider portions of the beach contain isolated colonies of strand species, mainly sand verbena, silver beachweed, and sea rocket. Strand species are adapted to salt spray, burial by wind-blown sand, low soil fertility, increased transpiration, a quickly receding water table, and the exposure of roots to the atmosphere (Martin, Emmett and Frederic Clements, 1939).

The coastal bluff vegetation is found on the steep eroding shale cliffs of the Sisquoc formation and on the seaward-facing areas of the coastal terrace. The plant species found here consist of those which can tolerate salt spray and wind from the ocean. Most of the cliffs are sparsely vegetated. Seablite is the most common cliff species. Cliff aster, endemic to the Gaviota area, but nonetheless common (Munz, P.A. and D.D. Keck, A California Flora, 1968) may also be found. The gullies and seaward-facing areas contain a mixture of coastal bluff species and shrubs from coastal sage communities. The most common species in these areas are California sagebrush, coast goldenbush, and chaparral broom.



Source: Federal Power Commission, 1975, Vol. III

Figure 8.2.1-31 Surface salinity at Avila, 1956-1968

The riparian woodland along Canada del Cojo on the site is dominated by deciduous trees which require an abundant soil moisture supply throughout the growing season. Arroyo willow is the dominant species in Canada del Cojo, with subdominant species such as elderberry, sycamore, white alder, and black cottonwood. Evergreen coast live oak occur scattered throughout the woodland. A California box elder was also observed along the stream. This species is mainly a tree of central California, and while it occurs sporadically in various parts of the Santa Ynez Drainage (Haller, John, 1975), this occurrence in Canada del Cojo is probably the only spontaneous strand along the south coast of Santa Barbara County (Smith, C.S., 1974).

Herbland and coastal sage scrub on the site is typical of that in the Transverse Ranges Province as discussed previously. Wild oats is the dominant species in herbland along with many other grasses and forbs. Coastal sage is dominated by California sagebrush with chaparral broom a common subdominant.

Pipeline Routes--The proposed pipeline routes, which consists of two proposals, Point Conception to Arvin (142.3 miles), and Arvin to Cajon (109.9 miles), would be situated in four general categories of vegetational formations: shrubland, woodland, herbland, and desert. These formations can be broken down into associations or communities. Shrubland is subdivided into coastal sage scrub and chaparral communities; woodland is subdivided into oak woodland, riparian woodland, and pinyon-juniper woodland communities; and the desert formation is subdivided into saltbrush scrub, creosote bush shrubland, joshua tree woodland, mesquite shrubland, and alkali sink communities. Herbland is a general term for land comprised of a variety of forbs, grasses, and, in some areas, small perennial shrubs. In addition, other communities with different species compositions would occur in marshland and salt flats in some of the above-mentioned formations. The species compositions of the communities which will be discussed in this section are representative of typical communities which have been observed along the proposed route. However, differences in topography, soil, and climate in areas of similar vegetation result in species compositions which differ from one locality to the other. All localities in any one community, such as chaparral or oak woodland, have similar growth forms and one or more dominant species in common. There are rarely any distinct boundaries between two different communities, but one community will gradually grade into another one, with a transition zone composed of species common to both.

The vegetaticnal composition of southern California is molded by a complex set of environmental conditions. Near the coast, marine moisture in the form of fog or rain is retained on the narrow coastal plain and in the mountains by the Transverse and Coast Ranges. Additionally, the maritime influence moderates temperatures near the coast. Thus, the coastal mountain ranges serve as a barrier between the more moist, milder climate of the coastal areas and the drier, more extreme climate of the interior regions. Superimposed on these elevational and water-related parameters are other factors influencing plant and animal distributional patterns. The interaction of climate and substrate creates a heterogeneous environment dominated by different vegetation types which, in turn, support a characteristic assemblage of animals.

The pipeline route would cross five biophysiographic provinces: Carrizo Plain-Temblor Range-San Joaquin Valley, Tehachapi Mountains, and Mojave Desert provinces. The designation of these provinces is based on differences in physiography, vegetation distribution patterns, changes in species composition, and disturbance history of the regions.

Each province is a mosaic of each of the communities listed, with the communities alternating with and grading into each other along the route as local environmental conditions change. Table 8.2.1.-36 lists the approximate number of miles of each vegetation community which would be traversed by the proposed route. The information on the species composition of the communities and the distribution of each community throughout most of the proposed route are based on infrared stereoscopic aerial photography and field work by Dames and Moore, the applicant's environmental consultants, and aerial and field inspections by the FPC staff. As of the writing of this report, no infrared photography or field work was done in the Carrizo Plain-Temblor Range-San Joaquin Valley province.

Transverse Ranges Province (first 45 miles)--The first 45 miles of the Point Conception to Arvin Route and the last 4.9 miles of the Arvin to Cajon route would be located in the Transverse Ranges Province. This province is comprised of coastal terrace and relatively low-elevation mountain and valley areas, all strongly influenced by the moderating influence of the Pacific Ocean. The last 4.9 miles will be described following the discussion of the Mojave Desert Province.

Of the initial 45 miles in this province, 13.6 miles are herbland, 10.3 miles are coastal sage scrub, 2.4 miles are oak woodland, 2.4 miles are chaparral, and 0.3 miles are barren (devoid of vegetation) with the remaining 14.2 miles consisting of cultural features (cultivated land, quarries, roads, etc.).

Herblands are composed primarily of introduced annuals from Mediterranean Eurasia which largely replaced native perennial grasses in California several centuries ago. They are generally found on soils grading from loam to clay with moderate to gentle slopes and southern exposures (Shipman, 1972). Herbland is extensively used for grazing and occupies an area greater in size than the original native grassland due to the conversion of shrubland to herbland by burning, cultivation, seeding, and other practices. The major grass components of the Transverse Ranges herbland are wild oats, ripgut brome, filaree, and farmer's foxtail, all introduced species. These occur along with less abundant forbs such as mustard and clover. In areas of intense grazing, less desirable nonforage species, such as shrubs and vinegar and dove weed develop extensive strands (Biswell, 1956). Mixtures of shrubland and woodland plants often occur in various densities with herbland. In persistently moist areas, sedges, mugwort, horsetail, spikerush, and nettle commonly produce well-developed stands. Herbland in this province grows under the wettest conditions of any along the proposed route. The grasses and forbs start growing in the fall when the rains begin in southern California. Grasses remain green until the beginning of the dry season around early summer, although forbs such as mustard will remain alive until nearly midsummer.

Coastal sage scrub, chaparral, and oak woodland communities are common in the hills and mountains of southern California and are found associated in an intricate pattern. The dominant species of coastal sage scrub are shallow-rooted shrubs which are usually under 5 feet in height. These plants tend to lose their leaves when the annual summer drought begins.

Coastal sage scrub is found at lower elevations than chaparral and is confined to areas near the coast, although it can occur as far inland as 50 miles. Most herbland areas contain scattered patches of scrub in gullies and on steeper parts of the hills. Scrub also occurs within chaparral, usually on disturbed areas or heavy clays. In the Transverse Ranges Province, the dominant coastal sage species consist of California sagebrush, purple sage, and black sage on drier areas and coyote brush, goldenbush, and

Table 8.2.1-36 Approximate distance in each vegetational community that would be traversed by the proposed route (distance in miles)

		Point Conception to Arvin			Arvin to Cajon			
	Community	Transverse Ranges Province	Southern Interior Coast Ranges Province	Carrizo Plain-Temblor Range-San Joaquin Valley Province	Tehachapi Mountains Province	Mojave Desert Province	Transverse Ranges Province	Total Miles
	Herbland	13.6	8.7	50	19.4	2.0	-	93.7
Shrubland —	Coastal sage scrub	10.3	2.1	-	-	-	-	12.4
	Chaparral	2.4	6.4	-	-	-	1.8	10.6
	Oak Woodland	4.2	0.9	5.8	1.3	-	-	12.2
Woodland	Juniper Woodland	-	-	-	0.8	-	2.1	2.9
	Saltbrush scrub	-	-	-	-	24.4	0.2	24.6
	Creosote bush	-	-	-	-	28.2	-	28.2
Desert	Joshua tree	-	-	-	-	2.2	-	2.2
	Creosote and Joshua	-	-	-	-	15.0	-	15.0
	Mesquite-alkali sink	-	-	-	-	0.2	-	0.2
	Cultural	14.2	1.9	21.5	8.5	2.0	0.8	48.9
	Barren	0.3	-	-	-	-	-	0.3
	Total Milage	45.0	20.0	77.3	30.0	74.0	4.9	251.2

Source: Federal Power Commission, 1975, Vol. III

coffeeberry on the wetter north slopes, usually close to the ocean. Smaller plants such as poison oak and elderberry are found associated with the dominant scrub species.

Chaparral communities tend to occur on warmer, dryer south slopes and are more common in inland mountains, rather than near the coast. They consist of a wide variety of larger shrubs which have long extensive root systems, dense branching, and thick evergreen leaves. Chaparral plants are able to maintain productivity throughout the entire year by utilizing water economically and keeping their leaves year-round.

Fire is an important aspect of chaparral communities and associated sage and woodland. Fires occur regularly in isolated areas of chaparral during the dry season from June through October. The various shrub species and accumulated litter will burn very rapidly; fire has been known to spread 6-1/2 miles in 4 hours (Cogswell, 1974). The major perennial chaparral species will resprout from the root crown following damage to the tops by fire or mechanical removal. The seeds of other species are stimulated by fire or by scarification of the seed coat. Fire is necessary for the occurrence of certain annual herbaceous species which could become extinct if there were not areas opened by fire. Where there has been resprouting, burned areas recover rapidly and are again covered with brush within 6 to 8 years (Sweeney, 1956). The chaparral community is extremely valuable in southern California for watershed protection. The deep roots hold the soil on the steep loosely consolidated slopes which would erode very quickly and cause severe flooding in the lowlands if they were not vegetated. The leaves and accumulated litter also absorb the impact of falling rain and add organic matter to the soil to maintain its structure. By holding rainfall on the slopes, it will percolate into the soil and recharge wells, streams, and reservoirs.

Chaparral in the Transverse Ranges Province is uncommon, forming significant stands only on the sandstones of the Santa Ynez Mountains near the start of the proposed route and on rocky slopes in the San Rafael Mountains between mileposts 35 and 40. Bigpod and greenbark ceanothus are the common dominant species in this province.

Oak woodland tends to occur on the cooler, moister north slopes. Coast live oak is the dominant tree in this province's woodlands. It can be found on nearly all exposures and substrates, occasionally forming a closed-canopy forest. The most widespread formation occurs approximately between mileposts 10 and 13 in the Santa Ynez Mountains and mileposts 20 and 24 in the Purisima Hills, and is composed of open stands of oak and toyon, with a well-developed undergrowth of coastal sage scrub and/or herbland. Valley oak occurs in open stands along river terraces and in the contiguous small valleys and hills of the Santa Ynez, Los Alamos, and Santa Maria Valleys. In canyons and on the lower north-facing slopes of the San Rafael Mountains are found dense formations of coast live oak, toyon, and California bay with scattered chaparral species. In the dry, south slope saddles below the ridges of these mountains, a few pure stands of blue oak may be found. Bigleaf maple, white alder, sycamore, box elder, cottonwood, and willow are the most common trees found in the riparian (streambank) areas. Willow thickets are common along lowland creeks and river channel borders. River channelization and agricultural development of floodplains have substantially reduced the extent of riparian woodlands.

Relict stands of plant species from northern coastal California occur along the route. These species include tanbark oak, salal, Pacific wax myrtle, and California huckleberry. The Point Conception area represents the biogeographic boundary between north and south California caused by the change in orientation of the coastline from northwest-southeast to east-west. As a result, many unique stands of north coast plant species can be found in the Santa Ynez Mountains. They occur primarily in chaparral and woodland, with some species in coastal sage scrub (Smith, 1949). Along the proposed route, the stands could be found between milepost 5 and milepost 15. These areas have been designated as "unusual communities of high scientific interest" by investigators who completed a biological inventory and evaluation of Santa Barbara County.

Southern Interior Coast Ranges Province--Mileposts 45 to 65 of the proposed route would traverse the Southern Interior Coast Ranges Province, a transitional mountainous zone between the woodland and brush-dominated mountains on the south and west and the semidesert herbland plants on the east. Of the 20 miles through this province, 8.7 miles are herblands, 6.4 miles are chaparral, 2.1 miles are coastal sage scrub, and 0.9 miles are woodland, with the remaining 1.9 miles consisting of cultural features. Portions of the Los Padres National Forest would be traversed from mileposts 44.2 to 44.9, 48.9 to 54.1, and 54.9 to 62.4.

The herbland in the Sierra Madre Mountains (around mileposts 45 to 55) is similar to that in the previous province, while that along the dry eastern slopes of the Caliente Range in the vicinity of milepost 60 is quite different, being relatively sparse and dominated by redstem filaree and red brome.

The best-developed chaparral along the entire route occurs in this province. It is dominated by chamise, buck brush, manzanita, mountain mahogany, and scrub oak. Chamise, often mixed with coastal sage scrub species, dominates many south-facing slopes throughout the province. Coastal sage scrub occurs in this province at or beyond its normal range of distribution. Black and purple sages and mulefat are more common in the scrub here than near the coast. A modified scrub vegetation consisting of basin sagebrush, rabbit brush, arrowweed, and mule fat supplements typical riparian vegetation along the Cuyama River. Oak woodland in the Southern Interior Coast Ranges Province is best developed in saddles and on north-facing slopes with gentle to moderate gradients. In ravines, it is occasionally mixed with chaparral. Coastal live oak, blue oak, and valley white oak are the most common tree species, with blue oak forming nearly pure stands in the drier areas such as in the Caliente Range.

A small area of serpentine soils is found in the vicinity of Aliso Creek between mileposts 46 and 48. While serpentine soils often support different species than those in adjacent non-serpentine soils and often have many endemic species no unusual biotic associations were observed here during a field observation. Furthermore, the proposed route appears to avoid the serpentine area.

Carrizo Plain-Temblor Range-San Joaquin Valley Province--From milepost 65 to milepost 142.3, the end of the initial route (Point Conception to Arvin), the proposed pipeline route would cross the Carrizo Plain-Temblor Range-San Joaquin Valley Province. This province has a semiarid to arid climate and the vegetation communities have a corresponding seasonal productivity less than that in the first two provinces. The province has been greatly disturbed by agriculture in the Carrizo Plain and the San Joaquin Valley and by grazing in most of the remainder of the province. It is estimated that about 50 miles of the route in this province is herbland, 21.5 miles is cultural land, and 5.8 is woodland.

Herbland in this province varies considerably along the route. Redstem filaree, Arabian grass, red brome, and foxtail grasses are the common annuals. Saltbush is an abundant co-dominant with these species on the plains and low hills. Other common small shrubs found include ephedra, bladderpod, and cheeseweed. Although an extensive freshwater marsh system once covered hundreds of square miles in the San Joaquin Valley, most of this has been reclaimed for farmland and only small remnants of marshes would be crossed by the proposed route. These would contain typical marsh species such as tule and rushes.

Salty alkaline flats which are wet in winter also occur in this province. The largest area of flats is Soda Lake Basin, about 2 miles north of the proposed route which contains species such as iodine bush, sea blite, sand spurry, and sea purslane. The proposed route may cross small alkaline flats ranging from 1 square yard to one acre in size with a similar composition. These seasonally-inundated flats, along with some seasonally-inundated freshwater pools which may also be crossed, can contain many endemic plant species which are not found in any other locality. The Tejon Hills which would be traversed by the proposed route from about milepost 137 to milepost 140.5 is an area of "significant natural botanic communities." This area, presently utilized for grazing, contains two rare endemic plant species and has an abundant wildflower population.

The woodland along the route in this province is not well-developed. It consists of scattered California juniper and deciduous oaks with an herbland understory. It could be found between mileposts 94 and 100 on the Temblor Range. In addition, trees such as Freemont cottonwood and willow occur along drains and irrigation systems in the two valleys.

Tehachapi Mountains Province--The second part (Arvin to Cajon) of the proposed route begins in this province at the proposed milepost 133.1 tie-in with the Point Conception to Arvin pipeline. The milepost numbering system starts back at 0 here. The route through this province extends to milepost 30. The proposed 108.9 mile route begins in the extreme southeastern edge of the San Joaquin Valley, crosses the southern portion of the Tejon Hills (avoiding the previously discussed "significant botanical communities") and traverses the Tehachapi Mountains. This province is less arid than the Carrizo Plain-Temblor Range-San Joaquin Valley Province and supports communities which are more biologically productive. Herbland comprises 19.4 miles of the route, cultural features comprise 8.5 miles, oak woodlands comprise 1.3 miles, and juniper woodland comprises 0.8 miles. Throughout this province, the valley areas are now utilized for either crops or resort-residential developments.

The herbland in the western foothills in the Tehachapi Mountains Province is similar in composition to that in the previous province, but has more variety. The quantity of shrubs in the herbland is less in this province than in the latter one. On the eastern slopes, fewer species are present and they produce less extensive cover. Desert annuals and shrubs grade from sporadic to common with decreasing elevation and unvegetated areas are more frequent and extensive. A few small marsh areas would be crossed by the proposed route, with species such as mule fat, willow, cypress, rush, and tule.

Two deciduous oak woodland communities would be crossed. One occurs between mileposts 4 and 5 near Tejon and Chanac Creeks and is dominated by valley oak and the other is near milepost 10 near Cummings Valley and is dominated by blue oak. California buckeye and an understory of chaparral species such as scrub oak and gooseberry are found associated with the oaks. In the riparian areas, species such as mule fat, sycamore, and Freemont cottonwood are found. As the route becomes more arid to the east, the oak woodland communities grade into pinyon-oak and then to pinyon-juniper, a transitional community between woodland and desert. Pinyon-juniper occurs around milepost 29. It is dominated by California juniper, pinyon pine, and Kern Joshua tree along with shrub species from desert, oak woodland, and chaparral communities.

Mojave Desert Province--The Mojave Desert Province would be traversed from milepost 32 to 104. The Mojave is an upland desert which lies in the rain shadow of the western coastal mountains. The section of the desert which the proposed route would cross is fairly smooth with an elevation ranging from 2,400 to 3,900 feet. The desert is crossed by many access roads, both paved and dirt, and the subsequent disturbance to the natural desert communities tends to be more severe than in the other provinces due to the fragility of the desert environment. In recent years, off-road vehicles have generated increasingly widespread and significant disturbance to the soils and biota, especially in the vicinity of Baldy Mesa (near milepost 104) and at scattered desert buttes (U.S. Bureau of Land Management, _Management Program for Recreational Vehicle Use of the California Desert_, 1973).

Due to the scarcity of water, the productivity of deserts is less than 10 percent of that for grasslands and dry forests (Odum, 1971). Individual plants are scattered in the desert with large seemingly bare areas between them. These bare areas often have mosses, algae, and lichens on them, which form a stabilizing crust on sands and other fine-grained soils (Odum, 1971). Desert plants have become adapted to the meager water supply by utilizing either of two methods, drought resistance and drought evasion. Some drought resistors, such as desert shrubs, can undergo dehydration without harm by shedding their leaves when water is unavailable. Other drought resistors include the cacti, which have reduced their evaporating surface by their characteristic shape and lack of leaves and which store water inside their thick fleshy stems. Drought evaders are annual plants which spend most of their lives as seeds, not sprouting until it rains.

Desert vegetation has the most diversified composition of any vegetation type in the United States. Worldwide, only tropical rainforests have a greater number of species (Greenwood and Edwards, 1973). Although many species can be found throughout this province, the composition varies greatly, depending on elevation, soil texture, drainage, and salt content, which results in the formation of a number of communities which can be described separately. About 24.4 miles of the proposed route would cross saltbrush scrub communities, 28.2 miles would cross creosote bush communities, 2 miles would cross herbland, 0.2 miles would cross mesquite-alkali sink communities, and the remaining 2 miles would cross cultural areas. In all of these communities, a large quantity of desert annuals occur. The composition and quantity of these species vary from year to year, depending on the rainfall and temperature of a particular year. The seeds of desert plants require a certain quantity of moisture before they will germinate, and in unfavorable years, annual species may not be found. During favorable years, they may form a nearly continuous carpet over many hundreds of acres (Twisselmann, 1967). Germination occurs from late autumn to early spring, with a growing season ranging from 6 weeks to 8 months, depending on the species (Beatley, 1967 and Went, F.W., 1948, 1949).

The creosote bush community is generally the most common association in the Mojave. This community is overwhelmingly dominated by creosote bush with an understory of the smaller saltbrush scrub species, especially burro weed, and desert annuals. Creosote bush is found on well-drained soils throughout the desert, particularly on upper alluvial slopes, but does not grow well on alkaline soils or in areas of extensive dune sand (Vasek, _et_ al., 1975). Individual creosote bushes may live over a thousand years by repeated sprouting from the root crown.

Saltbrush scrub (also known as shadscale shrub) is dominated by several species of saltbush, bud sage, desert tea, and several other shrub species. Many other shrubs, two types of grasses, and the desert annuals are also found. During the drought season, the leaves of most shrubs deteriorate. Saltbrush scrub is common on lower fine-grained and somewhat salty alluvial slopes and around playas (desert basins with interior drainage which collect water during heavy rains). Indian ricegrass is common in some sandy areas, occasionally forming patches of grassland.

Joshua tree woodland occurs as scattered individuals of Joshua trees on lower alluvial slopes and as relatively dense stands on well-drained upper slopes with adequate soil moisture. It is accompanied by an understory of saltbush scrub and desert annuals.

Mesquite and alkali sink communities occur around the sand dunes and playa lakes, mainly in the vicinity of mileposts 59 through 63 near Rogers Dry Lake. Mesquite is a shrub or small tree which is more common near dry stream courses further east. It has very large root systems which extend as much as 60 feet below the surface (Peattie, 1953). Mesquite stands occur on small sand dunes in these areas, and alkali sink communities occur in low-lying, seasonally inundated patches along the playa margins and also among the desert scrub. Species in alkali sinks include iodine bush, saltbush, salt grass, and alkali sacaton. The small amount of herbland in this province occurs near milepost 3 and represents a transition between the arid eastern herbland of the Tehachapi Mountains Province and saltbrush scrub.

In Los Angeles County, the proposed route from about mileposts 61 to 64 passes through an area designated as an important ecological area by the Los Angeles County Planning Commission. This area, on Edwards Air Force Base, consists of a large variety of desert ecosystems, including creosote bush scrub, Joshua tree woodland, salt flats, playa lakes, and mesquite-alkali sinks. The rare and endangered Calochortus striatus occurs here. Phacelia Wildflower Sanctuary is located about three-quarters of a mile northeast of milepost 67.5.

Transverse Ranges Province (last 4.9 miles)--The proposed route re-enters the Transverse Ranges Province near milepost 104 as it climbs up Baldy Mesa and enters the San Bernardino Mountains, where there is a marked increase in precipitation causing a change in the pattern of vegetation. This area has been disturbed in many places by road and right-of-way construction and off-road vehicle operation. This portion of the proposed route consists of 2.1 miles of juniper woodland, 1.8 miles of chaparral, 0.2 miles of saltbrush scrub, and 0.8 miles of cultural features. The last 2.8 miles would be in the San Bernardino National Forest.

Following the small quantity of saltbrush scrub (which contains scattered junipers) near milepost 104, a juniper woodland occurs for about the next 2 miles. It has California and Utah juniper as the dominant species with associated chaparral and desert species. The woodland is open with much bare ground around the junipers and shrubs. The rest of the land in the proposed route consists of a chaparral community with dominant species similar to the chaparral in the Transverse Ranges Province. However, it is relatively more open and junipers, Joshua trees, and desert shrubs occur sporadically. Near Cajon Summit at the terminus of the route, a fuel (fire) break and some highway slopes are vegetated by a needlegrass, a native perennial bunch-grass.

Rare or Endangered Flora--Based on the California Native Plant Society's Inventory of Rare and Endangered Vascular Plants of California, Table 8.2.1.-37, was compiled listing rare or endangered plant species which might occur near the proposed pipeline route and LNG site. Those species are known to occur within 30 miles of the proposed route in vegetational communities similar to those discussed in the vegetation section. In addition, two other species, Brodiaea coronaria var. Kernensis and Eastwoodia elegans are regarded as rare by local botonists (Twisselmann, 1967). These occur in the Carrizo Plain-San Joaquin Valley where much herbland is being converted to irrigated agriculture.

Wildlife

Regasification Plant Site--The animal species which utilize the proposed LNG site can be divided into two groups: inland species and ocean and shore species. The inland species are primarily herbland species, with smaller quantities of fauna associated with shrublands and riparian woodland. The composition of animal species for these communities is described in the section on fauna along the pipeline route.

A large variety of vertebrate animal species, almost entirely birds, utilize the ocean and shore for various activities. The primary species of the open ocean beyond the kelp beds include various species of gulls, terns, phalaropes, alcids, shearwaters, and storm petrels. In the vicinity of the kelp beds and nearshore waters, cormorants, herons, egrets, grebes, scoters, and brown pelicans occur. The ocean is utilized for feeding and resting, with breeding occurring on the Channel Islands and several isolated mainland sites. Most marine and shore birds feed on fish or invertebrates; many gulls are scavengers for surface carrion and refuse.

The coastal strand area is utilized extensively by birds. Shorebirds such as willets, marbled godwits, sanderlings, whimbrels, and black-bellied plovers feed and rest on it. Many gulls scavenge here and some of the other open ocean birds such as the brown pelican and various terns rest here. Some inland birds such as the water pipit, common crow, and various terns also utilize the strand area. The lack of a well-developed coastal strand community with dunes and associated vegetation excludes the use of this area by terrestrial vertebrates other than birds. The only exception is the striped skunk, which will feed on insects on the beach.

Pipeline Routes--The large variety of vegetational communities along the proposed route provide habitat for a correspondingly large variety of animal species. The larger carnivores such as coyotes tend to have a large distributional range in a variety of communities, whereas many of the small species tend to have a more restricted distribution. Rare, endangered, and other protected species are discussed in detail in the following section.

In the shrubland and oak woodland areas, the largest animal populations coincide with the rainy season. There are high bird populations until early summer when many species move to higher altitudes or areas which have greater subsurface moisture.

In general, population densities for many animal species decrease with distance inland along the route toward the more arid regions such as the Carrizo Plain-San Joaquin Valley and the Mojave Desert. While not in a true desert region, the fauna of the Carrizo Plain and San Joaquin Valley are derived from the desert regions of the southwest United States. Non-desert species can be found in the arid regions of the proposed route. However,

Table 8.2.1-37 Rare or endangered plants potentially occurring near the proposed pipeline route and LNG site

PROVINCE IN WHICH ENCOUNTERED: Species (a)	Comments (a), (b), (c), (d), (e), (f)
TRANSVERSE RANGES PROVINCE: (near Point Conception)	
Agrostis hooveri	San Luis Obispo and Santa Barbara Counties; foothill woodlands.
Eriodictyon capitatum	Endemic to Santa Barbara County; chaparral along ridges of western Santa Ynez Mountains. Found 1½ miles north of the proposed LNG site.
Scrophularia atrata	San Luis Obispo and Santa Barbara Counties; restricted to diatomaceous shales in coastal sage scrub and chaparral.
SOUTHERN INTERIOR COAST RANGES PROVINCE:	
Agrostis hooveri	San Luis Obispo and Santa Barbara Counties; foothill woodlands.
Atriplex vallicola	San Luis Obispo, Tulare, Kern, and Fresno Counties; valley grasslands in dried rainpools and flats.
Calochortus obispoensis	Endemic to San Luis Obispo County; chaparral.
Cardamine gambelli	Santa Barbara, Los Angeles, San Bernardino, Orange, and San Diego Counties; in wet places in chaparral and coastal sage scrub.
Carex obispoensis	Endemic to San Luis Obispo County, protected in Cuesta Ridge Botanical Area; restricted to wet serpentine soils in chaparral.
Monardella palmeri	San Luis Obispo and Monterey Counties, protected in Santa Lucia Cypress Grove and Cuesta Pass Botanical Area; on serpentine soils in foothill woodlands.
CARRIZO PLAIN-TEMBLOR RANGE-SAN JOAQUIN VALLEY PROVINCE:	
Amsinkia vernicosa var. *furcata*	San Benito, Kern, Fresno, and Kings Counties; chaparral, valley grassland, foothill woodland.
Atriplex tularensis	Endemic to Kern County, alkaline sinks and plains near Bakersfield.
A. vallicola	San Luis Obispo, Tulare, Kern, and Fresno Counties; valley grasslands in dried rainpools and flats.
Cirsium crassicaule	Kern, San Joaquin, and Mariposa Counties; shallow waters and wet places.
Cordylanthus mollis ssp. *hispidus*	Kern, Merced, and Solano Counties; alkaline places in valley grasslands.
Layia leucopappa	Endemic to Kern County; in scattered colonies on moist benches in valley and hillside herblands. Annual.
Lepidium jaredii	Kern, San Luis Opispo, Fresno, Kings, Monterey Counties; in herblands; collected 2 miles north of proposed route at south end of Soda Lake.
Lupinus horizontalis	Kern, San Luis Obispo, Fresno, and Inyo Counties; dry slope in interior valley grasslands.
Trichostema ovatum	Kern, San Luis Obispo, valley and hillside herblands.
TEHACHAPI MOUNTAINS PROVINCE:	
Eschscholzia procera	Endemic to Kern County; of very restricted occurrence; known only from sand flats near Kernville and from north of Tehachapi. Perennial.
Layia leucopappa	Endemic to Kern County; in scattered colonies on moist benches in valley and hillside herblands. Annual.
Mimulus pictus	Endemic to Kern County; of widespread occurrence on dry slopes around shrub patches and rock outcrops. Annual.
Perideridia pringlei	Kern, Los Angeles, Monterey, San Luis Obispo, Santa Barbara, Ventura counties; widespread in heavy clay soils in chaparral and oak woodland. Perennial.
MOJAVE DESERT PROVINCE:	
Calochortus striatus	Kern, Los Angeles, San Bernardino counties; of widespread occurrence in alkaline meadows, desert sink, and moister areas in saltbush scrub. Known from project area at Rogers Dry Lake. Perennial.
Chorizanthe spinosa	Kern, Los Angeles and San Bernardino counties; of widespread occurrence in creosote bush, Joshua tree and saltbush scrub.. Known from project area at Buckhorn Dry Lake. Annual.
Calystegia peirsonii	Endemic to Los Angeles County; of restricted occurrence in Joshua tree and creosote bush shrubland along the desert base of the San Gabriel Mountains. Perennial.
Cymopterus deserticola	Kern and San Bernardino counties; of widespread occurrence in creosote bush, Joshua tree, and saltbush scrub. Perennial.
Hemizonia arida	Endemic to Kern County; of very restricted occurrence; known from a sub-alkaline spring in Red Rock Canyon and from areas near Koehn Dry Lake and Mojave. Annual.
Puccinellia parishii	Endemic to San Bernardino County; of very restricted occurrence; known from alkaline seeps at Rabbit Springs (Lucern Valley) and near Kramer. Annual.
TRANSVERSE RANGES PROVINCE: (near Cajon)	
Chorizanthe leptoceras	Los Angeles, Riverside and San Bernardino counties; of widespread occurrence in sandy areas of soft chaparral. Annual.

Source: Federal Power Commission, 1975, Vol. III

many of the desert species are restricted to desert habitat and do not occur in the non-desert areas.

Much of the distribution and ecology of desert species has been explained in terms of adaptation to two conditions: intense heat and extreme aridity. As a consequence of these conditions, amphibians, which are easily dessicated, are uncommon. Birds, most of which cannot burrow to escape these conditions, are also relatively uncommon. Reptiles and small mammals, most of which burrow or utilize crevices to avoid extreme climatic conditions, are relatively abundant.

In this desert habitat, seasonality of climate and vegetative growth is pronounced. Many birds visit the Mojave Desert only during winter, or in spring and fall during migration. For most resident species, breeding periods are restricted to a brief period in spring. To avoid hostile conditions during much of the year, many species, such as the Mojave ground squirrel and desert tortoise, retreat underground in a semi-dormant state (Ingles, 1965 and Stebbins, 1966). Rainfall patterns are highly variable between years and within a given area, which results in large variations in vegetative growth and invertebrate populations which vertebrates utilize for food and/or shelter. As a consequence, vertebrate populations may fluctuate greatly in a given area (Beatley, 1969).

Mammals--The most common large carnivores along the proposed route are the coyote and the gray fox. The coyote is expected to occur in every terrestrial habitat along the proposed route. It adapts to a wide variety of environmental conditions and eats virtually anything with some nutritional value. The gray fox most likely occurs in woodland, shrubland, and the more heavily vegetated areas of the desert, but occasionally is found in open areas such as herbland. The rare and endangered San Joaquin kit fox is found in herbland in the Carrizo Plain-San Joaquin Valley area along the route. The desert kit fox is an uncommon inhabitant of the Mojave Desert portion of the route with a life history similar to that of the San Joaquin kit fox. The black bear is an uncommon inhabitant of woodland along the route. This part of California does not provide good habitat for black bears, which were introduced in the Los Padres National Forest area in the 1920's (Los Padres National Forest, 1975).

In the cat family, the bobcat and the mountain lion occur in woodland and shrubland. The bobcat preys mainly on small mammals and birds. The mountain lion preys on deer and smaller mammals. It is less common than the bobcat and occurs at higher elevations.

Mule deer are commonly found in woodland and shrubland and will occasionally browse in herbland. Where winters are cold such as in the Tehachapi Mountains, the deer occur in herds and migrate down to warmer winter feeding grounds. Where the climate is more moderate, such as in Los Padres National Forest, mule deer do not herd up, but form small groups near the tops of mountain ridges. In these areas, they usually stay all year in a home range 1 to 1-1/2 miles in diameter, although they occasionally drift down the ridges in winter (Los Padres National Forest, 1975). Mule deer utilize a variety of food sources from season to season. They feed on young sprouts of certain chaparral species in the winter and spring before the sprouts mature and are no longer tender. Herbland is grazed in winter and early spring when the grasses and forbs come up. They may eat leaves and twigs in orchards or from other deciduous trees and shrubs during the summer. In the fall, mule deer eat fallen acorns. In recent years, the population of the mule deer has been declining (Los Padres National Forest, 1975). No single reason has been pinpointed, but loss of habitat due to construction, land conversion to grazing and fire suppression plus the lack of predators (which usually help maintain quality in the population by eliminating weak individuals), and blockage of ancestral migration routes have been suggested (Los Padres National Forest, 1975 and Pacific Southwest Interagency Committee, 1971).

A large variety of smaller mammals inhabit the various communities along the proposed route, including raccoons, opossums, shrews, hares, rabbits, squirrels, mice, and rats. Rodents, rabbits, and hares can occur in every vegetational community along the proposed route often with different species in different communities. For example, in the squirrel family, the California ground squirrel is common in woodland and herbland, and occasionally can occur in the desert; the most common desert squirrel is the white-tailed antelope squirrel. In shrubland, the Merriam chipmunk is most common. Grassland species, such as the California meadow mouse and western harvest mouse, are generally replaced by kangaroo rats and pocket mice in arid regions along the route.

Birds--The large variety of bird species found in the vicinity of the proposed route is due to the migratory nature of birds. Some may inhabit an area only seasonally or temporarily visit an area during their migration, and some may be year-round residents. The presence of sections of the Pacific Flyway utilized by waterfowl during their spring and fall migrations occurs along that portion of the proposed route in the Carrizo Plain-Temblor Range-San Joaquin Valley Province, where most waterfowl would be expected to occur.

Most birds found in herbland communities only feed there and nest in woodland and shrubland communities. Common nesting birds in all herbland areas include the insect-eating western meadowlark, and the seed-eating mourning dove and lark sparrow. Large predators such as the red-tailed hawk and barn owl use the area for hunting small mammals. In the winter, species such as the white-crowned sparrow and western bluebird are abundant.

In shrubland, common ground-foraging birds include the California quail and wrentit which feed on seeds and insects. The wrentit and Bewick's wren are abundant insect feeders. Roadrunners are common in shrubland in the more arid parts of the proposed route.

Woodlands provide breeding and feeding habitat for the greatest variety of bird species of all the community types along the proposed route. Many of the common species found in herbland and shrubland also are found here. In oak and riparian woodlands, birds which feed on insects found on tree bark such as the acorn woodpecker, Nuttall woodpecker, and white-breasted nuthatch are found which do not occur in other habitats. Large raptors such as the Cooper's hawk and red-tailed hawk, feed in a variety of habitats but breed only in woodlands having tall trees. In woodland in the more arid inland regions along the route, generally from the Southern Interior Coast Ranges Province inward, deciduous oaks are common and birds such as the plain titmouse which feed on insects found on leaves are scarce in the winter. In the Carrizo Plain-Temblor Range-San Joaquin Valley and Tehachapi Mountains Provinces, desert species such as the phainopepla can also be found. The variety of bird fauna in juniper woodland is relatively impoverished in comparison to oak woodland but the evergreen trees provide year-round cover for some small birds. In winter, when insect populations are reduced, species such as the phainopepla and scrub jay feed extensively on juniper berries as well as on berries of mistletoe, which grows on juniper. The pinyon jay, while uncommon, is one of the most characteristic juniper woodland species, breeding only in this habitat.

In the Mojave Desert, bird densities are the lowest of all communities along the proposed route. Resident species throughout the desert are the black-throated sparrow, cactus wren, LeConte's thrasher, and roadrunner. Loggerhead shrike and American kestrel often hunt in desert scrub for insects, especially where tall shrubs or artificial structures afford perches. Large predatory birds and vultures, such as the common raven, red-tailed hawk, and turkey vulture, range widely over the desert but usually return to cliffs for roosting and nesting. In areas where drinking water is available, mourning doves, Gambel's quail, and house finches are commonly found. Most of the small resident bird species nest on the ground or in low shrubs. During winter, a number of species from moister habitats visit the desert, such as the white-crowned sparrow, western bluebird, and Audubon warbler. Numerous other bird species migrate through the Mojave Desert in spring and fall.

The distribution and abundance of many birds species is highly variable in the desert. The saltbush scrub portions of the desert are used by relatively few species (Small, 1974). Black-throated sparrow is probably the only common species in this habitat. In contrast, mesquite groves, which are represented south of the pipeline route on Edwards Air Force Base, commonly harbor several species of birds, including verdin, ash-throated flycatcher, and LeConte's thrasher. Phainopeplas, which feed on mistletoe berries, may be abundant. The thorny mesquite thickets provide well-protected nesting sites and cover. Migratory birds tend to follow patches of dense vegetation (Small, 1974). In response to the extreme variability of essential habitat resources, flocking among wintering species is particularly common (Cody, 1971), and localized aggregations of many of these birds may occur.

Where Joshua trees occur, several other bird species may be found. Many of these species are dependent upon or prefer Joshua trees for nesting. Examples are Scott's oriole, cactus wren, ash-throated flycatcher, common flicker, ladder-backed woodpecker, and American kestrel. These latter three species require cavities for nesting, which are afforded by Joshua trees. Also, Joshua trees provide observation perches used for hunting by the American kestrel and larger predatory birds.

High cliffs provide nesting sites for the golden eagle, red-tailed hawk, turkey vulture, and common raven which use rocky ledges as well as white-throated swift and prairie falcon which nest in holes on sheer cliff faces.

Owing to the extreme aridity of this province, birds often concentrate around aquatic features, like springs, watering troughs, and irrigated areas, which are visited daily in summer by flocks of mourning doves, Gamble's quail, chukar, and house finches. Since moist places often support an abundance of insects, swallows and other insect feeders are frequently attracted to these areas. The concentration of animal life around moist places attracts predators such as hawks and owls.

Marshes, reservoirs, canals, and temporary pools in the vicinity of the Carrizo Plain and the San Joaquin Valley support one of the largest populations of wintering waterfowl in North America (Kozlick, 1970) and serve as a stopover for migrating waterfowl. Wetlands have been reduced to only 10 percent or less than 500,000 acres, of their original acreage. Concurrent with these habitat changes crop depredation by waterfowl has increased greatly. No well-developed marshlands are crossed by the proposed route, but small marsh remnants and temporary pools probably would be crossed. Soda Lake, a large ephemeral lake, occurs about 2.5 miles north of the Point Conception to Arvin route at about milepost 70. It serves as a key wintering area for the lesser sandhill cranes, which feed on nearby dry grain fields (U.S. Bureau of Land Management, Unit Resource Analysis for the Temblor Caliente Planning Unit, 1972). In these valley wetlands, ducks, geese, and shorebirds, such as the mallard, pintail, green-winged teal, Canada goose, western sandpiper, and long-billed curlew are common in the winter. The American coot and killdeer are among several species which reside in this area year-round. Passeriform (perching) birds such as the long-billed marsh wren and red-winged blackbird also reside in the marshes, nesting in tule and cattail at the margins of wet areas.

In addition, near Rosamond Dry Lake on Edwards Air Force Base in the desert, ponds exist that may attract migratory waterfowl which migrate through this region of the Mojave Desert. During the winter months, mallard and other ducks, as well as shorebirds such as western sandpaper and willet, are expected. When playa lakes contain water, waterfowl and shorebirds are attracted to these areas.

Reptiles and Amphibians--Reptiles are common in most areas along the proposed route. They are the least abundant in the herbland in the Transverse Ranges and Southern Interior Coast Ranges Provinces, which are less arid then in the other portions of the route. Many reptilian species including the western fence lizard, gopher snake, and southern alligator lizard do occur in shrubland and woodland in those provinces. The western pond turtle and common garter snake are common inhabitants in or near aquatic areas.

Further inland along the route toward the desert, reptiles are more important aspects of the fauna. Unlike herbland in the first two provinces, the semi-desert herbland of the Carrizo Plain-Temblor Range-San Joaquin Valley Province is well represented with reptiles such as the sideblotched lizard, western whiptail, gopher snake, and western rattlesnake. In woodland, the western fence lizard, glossy snake, gopher snake, and western rattlesnake are common.

In the Tehachapi Mountains Province, reptiles occur frequently; desert species like the sagebrush lizard and the desert night lizard, found in pinyon-juniper woodland, occur commonly for the first time along the route. The extreme heat and minimal water in the Mojave Desert make it very difficult for warm-blooded animals to maintain a constant temperature. As a result, reptiles, especially lizards, are the most abundant desert vertebrates, occupying nearly every type of habitat (Mayhew, 1968). For many species of desert reptiles, characteristics of the substrate as well as vegetation are often implicated as major determinants of species distribution (Stebbins, 1954). Although these characteristics vary considerably over the Mojave Desert, a number of reptile species are common throughout most of the desert. Zebra-tailed lizard, western whiptail, and sideblotched lizard are common ground-dwelling lizards. The longnosed leopard lizard occurs infrequently, often feeding on smaller lizards. Common snakes are the gopher snake, glossy snake, common king snake, and Mojave rattlesnake.

Other desert reptilian species have more restrictive habitat requirements. The long-tailed brush lizard occurs almost exclusively on large shrubs, chiefly creosote bush and mesquite. In areas with a sandy substrate, which occur mainly in washes or in the vicinity of dry lakes, a number of other reptiles are common. Examples are the desert horned lizard, desert iguana, western shovel-nosed snake, and sidewinder. The California legless lizard lives in loose soil and sandy areas with plant cover; a few populations are known on the western edge of the Mojave Desert (Bury, 1972). In Joshua tree areas, desert night lizards commonly spend much of their lives beneath limbs and trunks of fallen Joshua trees. The banded gecko, collared lizard, chuckwalla, and speckled rattlesnake occur primarily in rocky areas such as canyons and buttes. The desert tortoise, a protected species, occasionally occurs in shrubland. Lizards and the tortoise are mainly active during the day, although they seek shade during midday in summer. Most desert snakes are only active at night. Desert reptiles usually pass the cold winter season in a semi-dormant state in burrows or crevices.

Amphibians are scarce along most of the proposed route due to the dryness of the region. They are most common in aquatic areas and oak woodland. The bullfrog, California newt, western toad, and Pacific tree frog are common in and near aquatic areas along the route, mainly in the first two biophysiographic provinces. Woodland in these provinces is moist enough to support several amphibians, notably the California newt and California slender salamander. The salamander lives under logs, rocks, or leaf litter, laying eggs underground. The newt occupies similar habitat, but lives closer to streams and lays eggs in the water where the larvae develop. Oak woodland in the Tehachapi Mountains Province also provides habitat for the California slender salamander, ensatina, and arboreal salamander, all with similar life histories. Throughout the other areas along the proposed route, amphibians are virtually non-existent except for temporary aquatic areas. These, however, do occur sporadically all along the route, and thus some amphibians (only frogs and toads) can even be found in the desert areas. The California tree frog and the Pacific tree frog can be found near temporary streams and springs along the border of the Mojave Desert. The southwestern toad is known to occur along the Mojave River, several miles east of the proposed route. Desert amphibians estivate in moist earth during the summer and emerge following rain to lay eggs.

Natural Areas and Wildlife Refuges--The Point Conception to Arvin segment passes through three segments of the Temblor National Cooperative Land and Wildlife Management Area between mileposts 96 and 100 for a total of about 2.9 miles. The particular wildlife species which are managed here include the chukar, California quail, mourning dove, and a small population of mule deer (Wallace, 1974). Wildlife populations fluctuate tremendously as a result of the large variation in annual precipitation. In an effort to stabilize these fluctuations and increase game populations, a number of water catchments have been constructed at scattered localities (Wallace, 1974).

The U.S. Bureau of Land Management has proposed that their holdings on Soda Lake (described in the previous section on wildlife) be designated a wildlife management area or wildlife refuge. To provide a buffer for managing this habitat, they have recommended the acquisition of some of the land around the lake.

In San Bernardino County, the Arvin to Cajon segment would traverse two areas from mileposts 80 to 90 designated by the county for "special design" use by off-road vehicles. These areas have a "medium" to "high" resource value due to the occurrence of the desert tortoise and Mojave ground squirrel, described in the following section.

Freshwater Species--The proposed pipeline route would cross about 43 rivers, streams, washes, and arroyos, each of which usually ceases to flow during some portion of the year. Limited fish populations occur in the larger streams along the route, particularly the Santa Ynez River, Sisquoc River, and Cuyama River. Species found would be typical of warm water streams, such as bass, crappie, sunfish, catfish, and carp. Streams which flow to the ocean contain anadromous fish, mainly steelhead trout (Pacific

Southwest Inter-Agency Committee, 1971). Some stocking of streams for fishermen occurs along the proposed route.

Marine Biota--

1. Marine Vertebrates. The Point Conception region represents an interesting area in that it is the range limit of many of the colder (boreal) and warmer (temperate) water fish. Temperature variations in this region allow a mixing of the two faunas during different times of the year. Seventeen of 268 species of marine fish which could be present in the area have a northern or southern range limit at or within 10 miles of Point Conception.

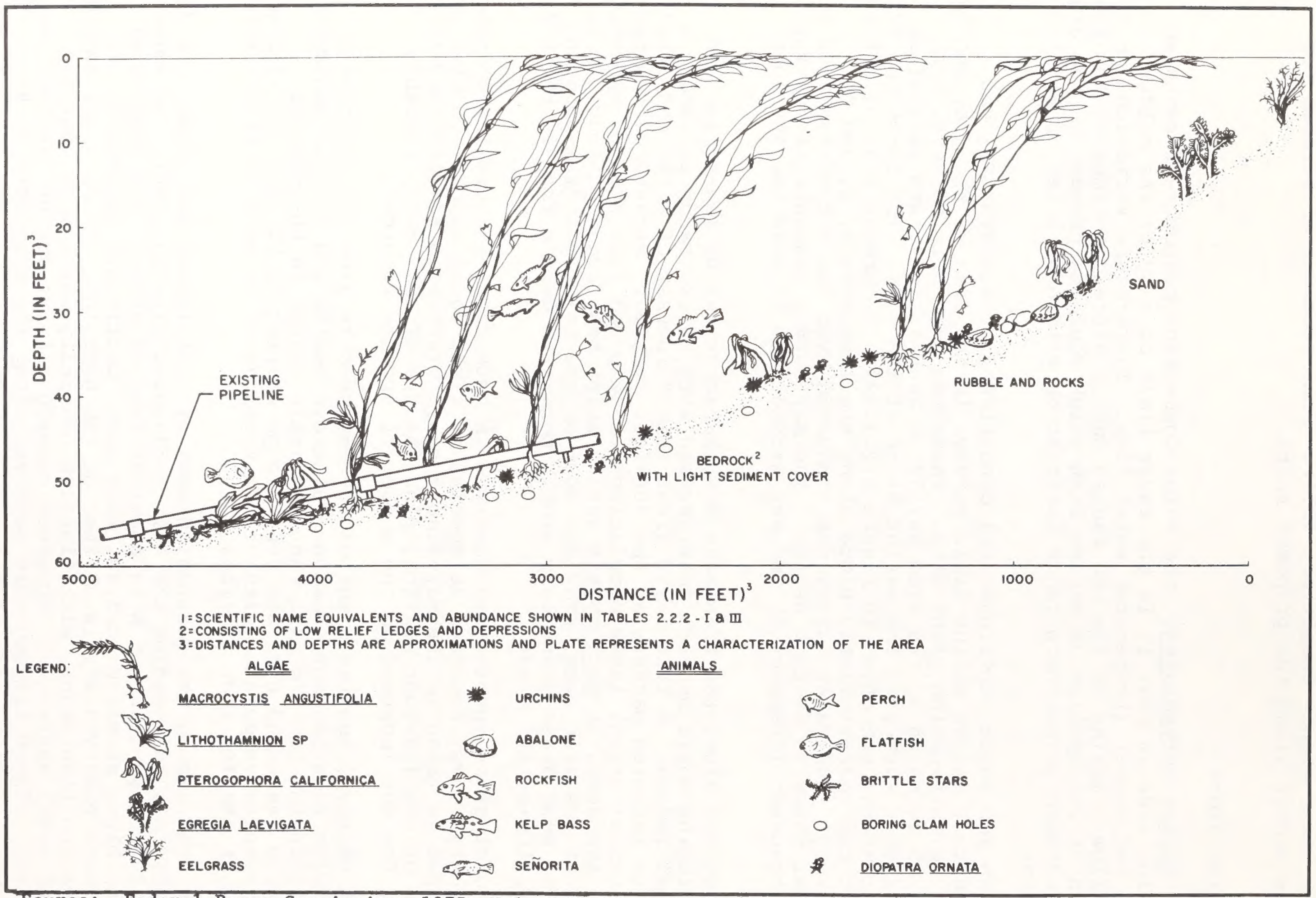
Dames and Moore, environmental consultant for Western LNG, has completed two, 1-week marine field surveys in the area of the proposed LNG terminal regasification plant site. These two quarterly surveys, from February 25 to March 1, and from May 30 to June 4, 1974, are part of an ongoing 2-year survey of the marine biota of the site. The locations of the survey transects are shown in Figure 8.2.1.-32. Figures 8.2.1.-33, 34 and 35 depict the characteristic biota along the transects A, B, and C, respectively. The March survey was conducted over the three transects from intertidal zones to 60-foot depths. The May survey concentrated on the central transect (Transect A) and was extended to include the 100-foot contour.

Substrata along the transects are characterized by low-relief and gently sloping shale bedrock interspersed with thick, sandy patches and occasional ledges. A thin layer (less than 4 inches) of silty mud overlays bedrock in isolated patches at the 100-foot station. Because of the paucity of high-relief areas, large populations of kelp-bed fish are not expected to occur in the area. A Macrocystis (giant kelp) bed, running along the entire frontage of the site area, provides most of the cover for free-swimming fish. The most dense giant kelp growth occurs in depths from 30 to 60 feet on rocky, low-relief areas.

A total of 46 species was observed in both Dames & Moore field surveys. The February survey recorded 26 species of fish, 16 of which were also among the 36 species taken in the May-June survey. Increased sampling and the addition of the 100-foot station, plus the use of gill nets, probably accounts for the increase in the number of species recorded.

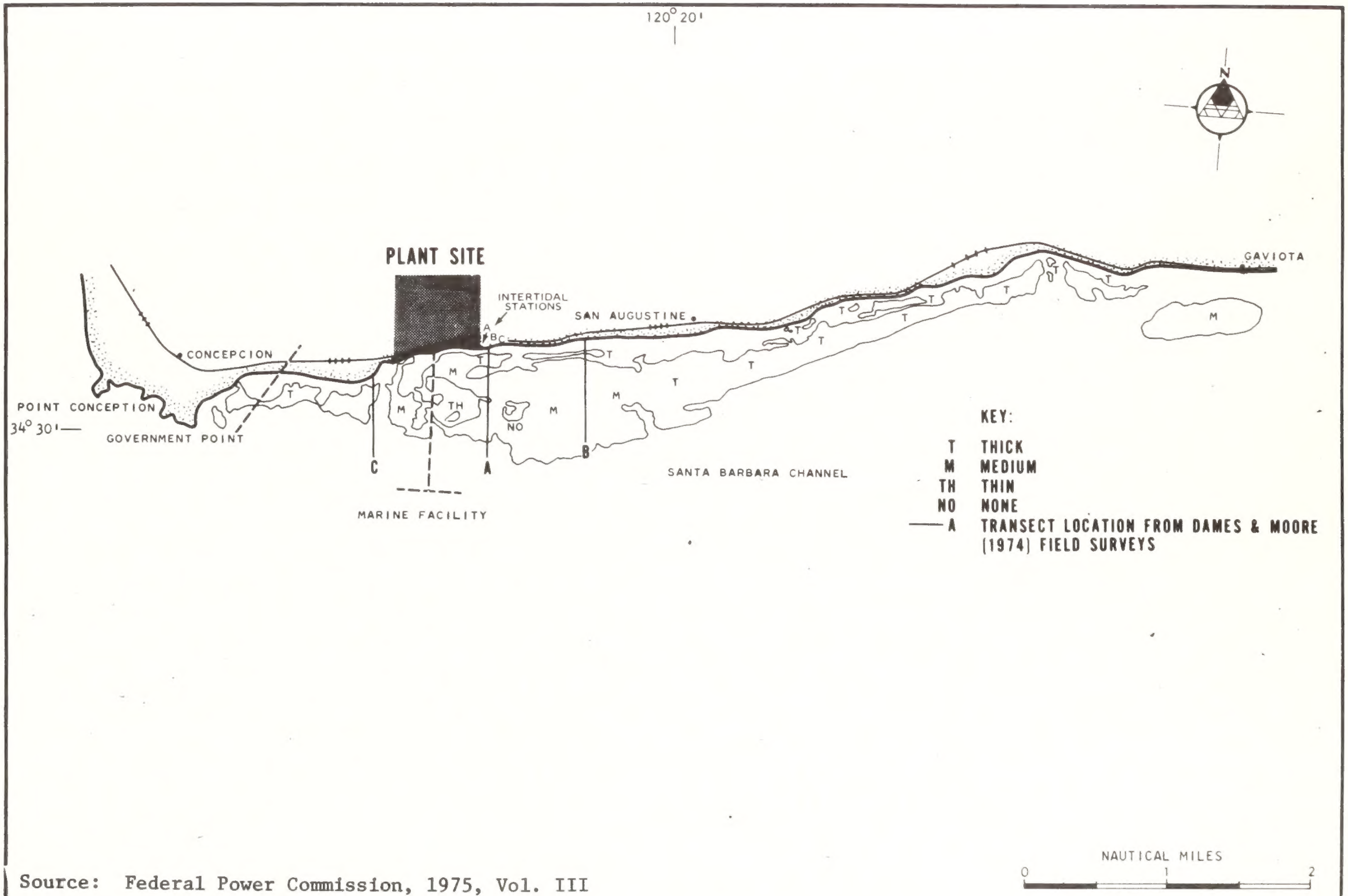
The observed aquatic fauna of the entire site area was relatively scarce, with rockfish most common. Blackeye gobies and Pacific sanddabs characterize the benthic fish fauna. Little change in the species composition was found over the depth range sampled by biologists, although several species associated with deeper water (such as rosy rockfish) were observed at the 100-foot station.

The area having the greatest number of individuals and species of fish was immediately surrounding the 6-inch-diameter pipeline, which traverses diagonally across Transect A in about 40 feet of water. Six species of rockfish, black perch, senoritas, kelp bass, California sheephead, and lingcod were observed within 30 feet of the pipeline. Other areas supported a less varied fish fauna, with flatfish generally being most numerous. Angel and swell sharks were observed occasionally at depths ranging from 40 to 100 feet. Three lingcod were observed along the transects in 40 to 60 feet of water. Along Transects A and C, in depths of 20 and 40 feet, small schools of senoritas were observed. These schools were within the kelp forest approximately 10 feet above the bottom.



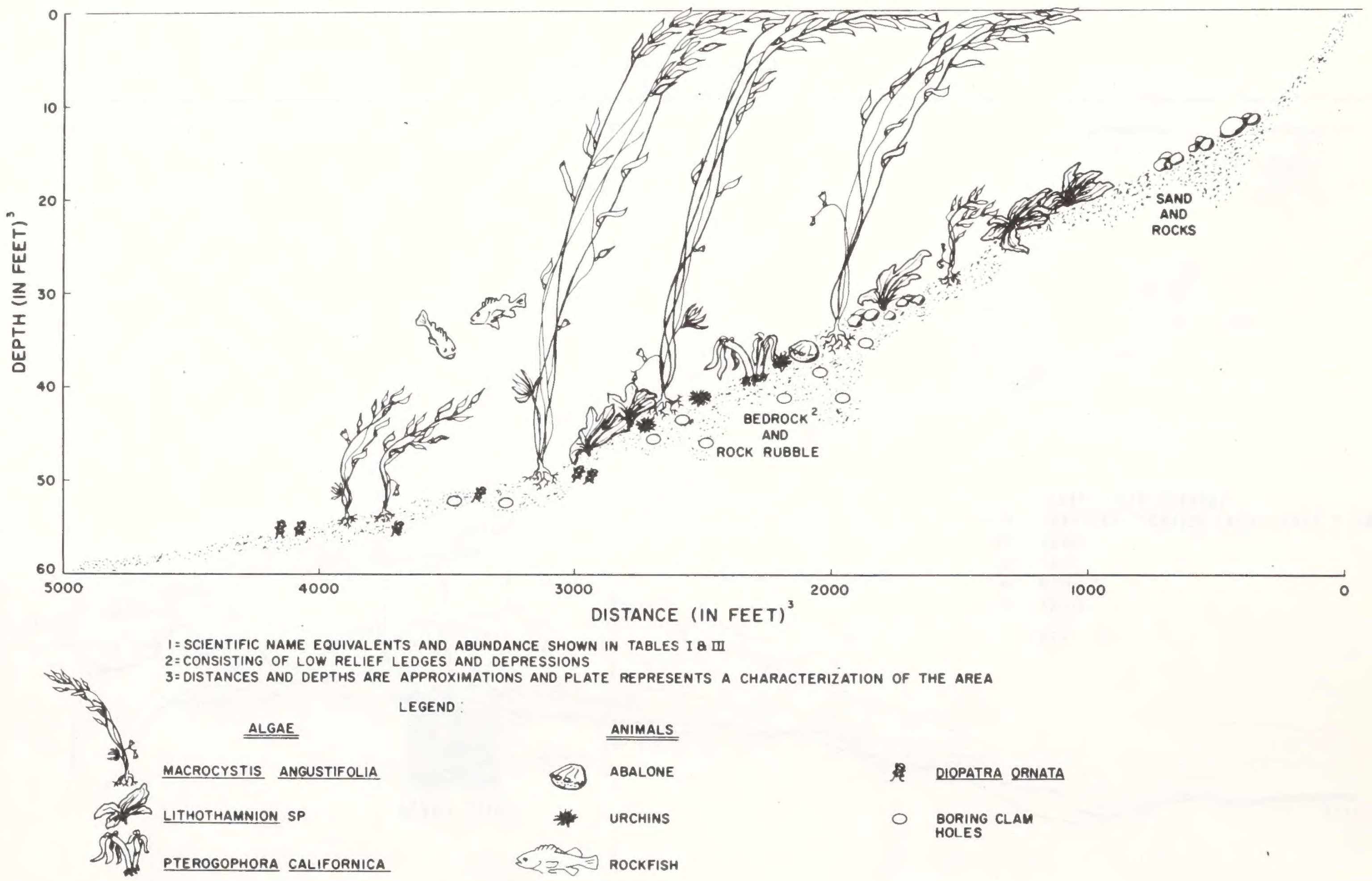
Source: Federal Power Commission, 1975, Vol. III

Figure 8.2.1-33 Transect A - plant and animal distribution



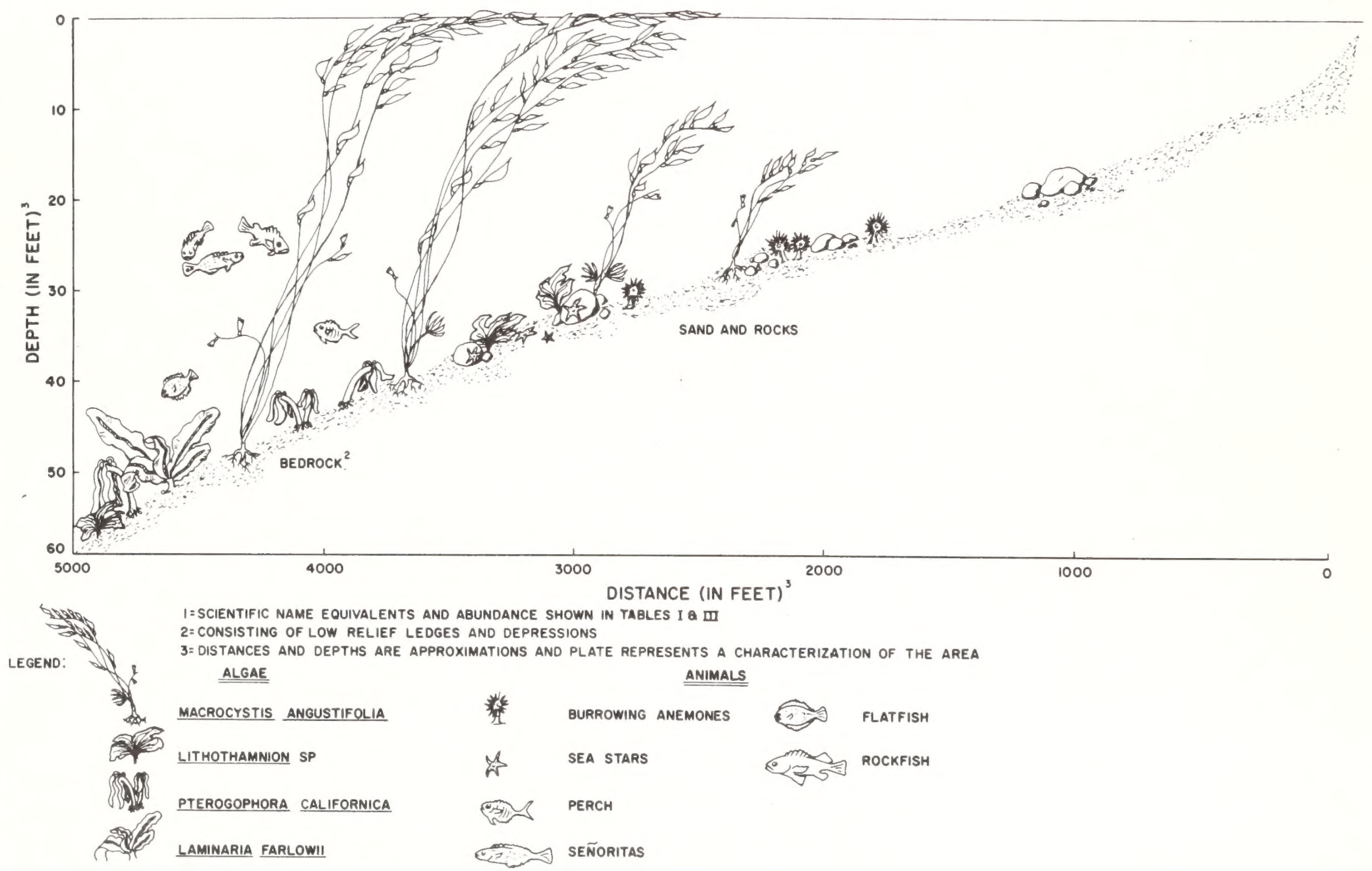
Source: Federal Power Commission, 1975, Vol. III

Figure 8.2.1-32 Kelp bed density: Point Conception to Gaviota



Source: Federal Power Commission, 1975, Vol. III

Figure 8.2.1-34 Transect B - plant and animal distribution



Source: Federal Power Commission, 1975, Vol. III

Figure 8.2.1-35 Transect C - plant and animal distribution

1. Marine Invertebrates.

a. Benthos. From the field surveys in February and May, 1974, 481 species of benthic biota have been recognized. A survey of existing marine biological literature for the site area revealed 514 species of which 194 are shared with the Dames & Moore survey findings. Combining the literature and field results yields a known biota consisting of 853 species, of which 676 are invertebrates; 176, algae; and 1, a flowering plant.

Ectoprocts (moss animals, 57/676, 8 percent), gastropod molluscs (snails and nudibranchs, 102/676, 15 percent), and polychaetous annelids (bristle worms, 164/676, 24 percent) account for nearly half of all the invertebrates reported.

From six other taxonomic groups (sponges, coelenterates, clams, and three groups of crustaceans), more than 20 taxa have been reported for the site area. The relatively ample representation (87 species, 13 percent) by microcrustaceans (amphipods, isopods, cumaceans, ostracods, and tanaids) is indicative of the contribution to the biota from sediment inhabitants. The clams (49 species, 7 percent) are also indicative of the availability of viable sedimentary habitat.

Along the transect at the proposed pier location (Transect A, Figure 8.2.1-33) three distinct subtidal biotic assemblages exist. From depths of 6 to 20 feet, the bottom has a relatively high relief (compared to the remainder of the transect) with isolated boulders and rock piles to about 6 feet in height. Sand patches are numerous, and are probably coarser than those farther offshore. Invertebrates are: starfish (Pisaster, Patiria, Dermasterias, and Pycnopodia), abalone, hydroids, and anemones. Lobster and rock crabs are less common.

From 30 to 55 feet deep, areas characterized by the presence of Macrocystis (giant kelp), the benthic macrofauna appear more varied than those farther inshore. Conspicuous invertebrates are abalone, sea urchins (which occur in tightly packed patches of up to more than 100 individuals and dominate all raised relief areas) cowries, boring clams (especially Parapholas), tube building worms (Diopatra), chitons (particularly Isachnochiton and Tonicella), rock crabs, and the same four starfish as in the shallower water. Less common are the snails Kelletia, Mitrella, and Calliostoma; a variety of nudibranchs (including Dendrodoris, Anisodoris, Acanthodoris, Flabellinopsis, Hermissenda, Diaulula, Dendronotus, Cadlina, Phidiana, and Triopha); solitary corals (Paracyathus); colonial anemones (Corynactis); hydroids; hermit crabs; and the starfish Mediaster.

The transition zone from the kelp bed to open bottom occurs from water depths of 55 to 70 feet. The substrate and macrofauna continue to be similar to that of the kelp areas, even though the Macrocystis fails to create a canopy (that is, reach the surface) in this depth range.

The deeper area from 70 to 105 feet has no dominant benthic species. Most numerous are solitary corals (Paracyathus) and boring clams (especially Lithophaga). The most conspicuous invertebrates are large anemones (Tealia and Metridium) and sponges (Geodia), occasional rock crabs and abalone, patches of sea urchins, the tectibranch mollusc Tochuina tetraquetra, and starfish (Patiria, Pisaster, Pycnopodia, Mediaster, and Dermasterias). The white anemone (Metridium), an irridescent red alga (Drouetia), and the California sea cucumber (Parastichopus californicus) were unique to this depth range. All three are characteristic of deeper water in southern California.

The lateral continuity of the communities was investigated by surveying transects approximately 4,000 feet up and downcoast parallel to the proposed pier location. These observations were made to determine gross macrofaunal similarities. The upcoast transect (Transect C) has more sediment and shale shingles offshore (55 to 65 feet) than Transect A. The downcoast transect (Transect B) is similar to Transect A but with less available sediment. The substrate is nearly solid shale pavement with almost no rocky vertical relief. The extensive solid substrate allows a high degree of development for epifaunal species, but the available sediment is still sufficient to permit a varied infaunal component along all three transects.

b. Intertidal Invertebrates. The intertidal zone in the immediate area of the proposed LNG terminal regasification plant encompasses three more or less distinct habitats: sand, sand and bedrock, and exposed rocky areas. To assess the macrofauna of each habitat, three intertidal sampling stations were established. These stations, identified as Station A, B, and C, were located west to east, respectively, in the area of Transect A. Of the 88 species of intertidal organisms identified from the Dames and Moore surveys, 54 were invertebrates. Previous studies of intertidal biota in the region have centered on the rocky areas at Government Point (approximately 2 miles west of the site) and at Gaviota (approximately 10 miles east of the site). Gastropod mollusks (snails, 11/54, 20 percent), polychaetous annelids (bristle worms, 12/54, 22 percent), and crustaceans (amphipods, isopods, crabs, and barnacles, 12/54, 20 percent) dominate the intertidal invertebrate species. Echinoderms are represented only by two species (Strongylocentrotus purpuratus and Pisaster ochraceus), and both of these are found low in the intertidal zone.

Intertidal Station C (see Figure 8.2.1.-32) supported the most varied fauna of any of the surveyed areas. This area is characterized by a large rocky area exposed to wave action and supporting both tide pool and exposed face fauna.

Table 8.2.1.-38 gives the distribution of space utilization on the only two large reef rocks in the site area which are located at intertidal Stations B and C in Figure 8.2.1-32. Mussels of the genus Mytilus are the dominant inverbrates. The barnacle Chthamalus fissus is the only other invertebrate species recorded with more than 10 percent coverage. Coverage is used as a dominance criterion, since space is usually the limiting environmental parameter in habitable rocky intertidal areas.

The lower rocky intertidal levels were characterized by boring clams (Lithophaga and Adula), snails (Olivella), and hermit crabs (Pagurus). The midtidal rocky assemblage was dominated by the mussels (Mytilus) and barnacles (Pollicipes and Chthamalus). Mobile fauna were represented by species of the limpet genus Collisella (especially C. scabra and C. digitalis), the snails Tegula and Littorina, the chiton Mopalia, and the shore crab.

On the lee side of the reef rock at C, a large patch of the sand tube building worm Phragmatopoma has developed.

Twelve species of invertebrates in the intertidal zone have a high relative abundance. Half of the 12 more abundant invertebrates are snails (4 species of limpets, Collisella, plus Tegula and Littorina), 3 of the abundant species are the sand dominants discussed earlier in this section, and the others are a mussel, a sand tube building worm, and a stalked barnacle.

Table 8.2.1-38 Percent coverage by intertidal reef rocks

	Percent Coverage[2]	
Category	B	C
Enteromorpha spp. (green algae)	11.1	0
Ulva spp. (green algae)	0	26.8
Chondria nidifica (red alga)	0	1.8
Porphyra perforata (red alga)	0	1.8
Anthopleura elegantissima (colonial anemone)	0	1.8
Collisella digitalis (limpet)	5.6	0
Mytilus californianus (mussel)	2.8	69.9
Balanus glandula (barnacle)	0	1.8
Chthamalus fissus (barnacle)	13.90	10.7
Tide Pools	5.6	7.1
Uncolonized Rock Surface	61.0	17.9
	100.0	139.6[3]

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[2] Percent coverage based on point samples taken two every meter along transects from the midpoints of the reef both parallel and perpendicular to the wave direction; 36 points at b and 56 points at c.

[3] Coverage figure of >100% at c arises from epizoic habits of *Chthamalus fissus* and *Ulva* spp.; 34% of samples were occupied by two species.

Source: Federal Power Commission, 1975, Vol. III

The sandy beach fauna had 3 dominants in the May samples: the beach hopper (Orchestoidea), an isopod (Excirolana), and the sand crab (Emerita). In the February samples, no dominant sandy beach species were found at the lower levels. Orchestoidea was dominant in the dry sand.

Rare and Endangered Marine Species--No list of rare or endangered species for algae or marine invertebrates exists. None of the fish species listed by the U.S. Department of Interior (1973) or the California Department of Fish and Game (1974) are expected to be found on the site or in the immediate marine vicinity.

The National Marine Fisheries Service (1973) states that all marine mammals are protected, or that their harvesting is at best managed. With the exception of the harbor seal, no marine mammals are expected either to use the site as hauling grounds or to appear regularly on the site.

Many species of rare or endangered cetaceans (whales, dolphins, and porpoises) are found along the coast of southern California. Species and population numbers fluctuate seasonally because most of the marine mammals are migratory. Between October and April, the most numerous species in decreasing order of abundance are the common dolphin, the Pacific white-sided dolphin, and the northern right whale dolphin. The Pacific pilot whale, the Pacific bottle-nose dolphin, and the Dall porpoise are less abundant, occurring in about equal numbers. The gray whale, the blue whale, and the finback whale are found in the area and are listed as endangered species. There is little firm information available concerning whale population numbers in the channel, but estimates are being prepared by Biosystems Program, Naval Undersea Center, San Diego, California. Sea otters are also found in this region. Additional information on the marine mammal populations along coastal southern California is available in a recent report by the Department of Commerce (1974).

Several species of pinnipeds including the California sea lion, Stellar sea lion, harbor seal, northern elephant seal, and northern fur seal occur in the Santa Barbara Channel.

Rare, Endangered, or Protected Species--Nine vertebrate animal species designated by the U.S. Department of the Interior (USDI) or the State of California as rare or endangered could be found in the vicinity of the proposed terminal and/or pipeline. In addition, seven species in this area are categorized by California as protected. These rare, endangered and protected species are listed in Table 8.2.1.-39. A protected species is one which may not be endangered, but could become rare in the future, if not protected. Such species may not be hunted in the state.

The San Joaquin kit fox, endangered according to the USDI and rare according to the State of California, is restricted to the San Joaquin Valley, including the Carrizo Plain, and the surrounding hills. This includes areas where the proposed pipeline would pass through from about mileposts 61 to 65, 68 and 86, 89 to 94, and 100 to 120 of the Point Conception to Arvin segment. The San Joaquin kit fox is restricted to areas of native vegetation which support kangaroo rats, their main source of food. Conversion of formerly dry valley land to irrigated agriculture has considerably reduced its range, with a 34 percent reduction of habitat between 1960 and 1970 alone. There are presently only about 3,000 square miles of suitable habitat remaining which supports an estimated population of between 1,000 and 3,000 adult foxes. Illegal shooting of the San Joaquin kit fox is another threat to this animal's survival. In addition, many are killed by automobiles when the foxes are forced to scavenge along the road

Table 8.2.1-39 Rare, endangered, or protected animal species in the project area

Rare and Endangered

Mammals

San Joaquin kit fox *Vulpes macrotis mutica*
Mojave ground squirrel *Citellus mohavensis*

Birds

California least tern *Sterna albifrons browni*
California brown pelican *Pelecanus occidentalis californicus*
California condor *Gymnogyps californianus*
American peregrine falcon *Falco peregrinus anatum*
Southern bald eagle *Haliaeetus leucocephalus leucocephalus*

Reptiles

Blunt-nosed leopard lizard *Crotaphytus wislizenii silus*

Amphibians

Tehachapi slender salamander *Batrachoseps stebbinsi*

Protected

Mammals

Ringtail *Bassariscus astutus*

Birds

Sandhill crane *Grus canadensis*
White-tailed kite *Elanus leucurus*

Reptiles

Desert tortoise *Gopherus agassizi*

Amphibians

Southwestern toad *Bufo microscaphus*
Red-legged frog *Rena a rora*
Ensatina *Ensatina eschscholtzi*

Source: Federal Power Commission, 1975, Vol. III

for roadkilled rabbits because of low kangaroo rat populations. The kit fox is a nocturnal animal, spending the day inside a den or burrow system. The fox prefers open, level, sandy ground for den construction. At any given time, most dens are vacant. During the breeding season from October to June, the larger dens in the area are occupied by breeding pairs, who change dens once or twice a month. From June through October, most adult kit foxes are solitary and may use four or five different dens each month (U.S. Department of the Interior, Threatened Wildlife of the United States, 1973; California Department of Fish and Game, At the Crossroads, 1974; Morrell, 1972; and Laughrin, 1970).

The Mojave ground squirrel, classified as rare according to the State of California, occurs in creosote bush communities in the Victorville-Barstow-China Lake region of the Mojave Desert. Increasing urbanization in this section of the desert is destroying most of its habitat in the Mojave River basin and Antelope Valley. Only four active areas inhabited by the Mojave ground squirrel are now known; one of these is 3.5 miles north-northwest of milepost 83 near the Shadow Mountains. Since the habitat requirements and distribution of the species have not yet been accurately determined, all of the creosote bush areas east of the town of Mojave (mileposts 38 to 100) are considered potential habitat for this species. It is a diurnal (active during the day) mammal which feeds mainly on seeds, fruits, and nuts. It breeds after emerging from a period of dormancy which lasts from August to March, during which time there is little food available (California Department of Fish and Game, At the Crossroads, 1974; Ingles, 1965; and Hoyt, 1972).

The ringtail, a close relative of the raccoon, is protected by the State of California. It is almost entirely nocturnal and feeds on rodents, other small animals, and fruit. The ringtail is an uncommon mammal, even though it occurs from southern Oregon to Mexico. The ringtail inhabits brushland in the area of the proposed pipeline and LNG terminal site, but is not found in the central valleys or the deserts. It is protected because it is trapped for fur. Caves and crevices in cliffs are common denning locations; it may also den in hollow trees. The young are born in May or June (Ingles, 1965 and Cahalane, 1961).

The California least tern is classified as endangered by both the USDI and the State of California. It nests on isolated beaches and sand bars along the southern California coast which are free from human disturbance and vegetation. Formerly, nesting colonies were more numerous, but, at present, colonies in Santa Barbara County are restricted to the Santa Ynez River mouth; the proposed regasification plant site is not a nesting site for this species. Least terns migrating to or from the southern hemisphere may occur anywhere along the coast and have been reported as "rare" in wetlands of the San Joaquin Valley, possibly near the proposed route. The primary threat to this species is loss of nesting habitat caused by human disturbance (California Department of Fish and Game, At the Crossroads, 1974; Bender, 1973; and U.S. Bureau of Sports Fisheries).

The California brown pelican is classified as endangered. It nests on the Channel Islands, on coastal islands off lower California, and in the Gulf of California. California's last nesting colony, on Anacapa Island, may be incapable of maintaining itself. Its decline is due to collapse of thin shelled eggs during incubation as a result of pesticides and other pollutants. This pelican is commonly seen along the coast and nearby offshore, resting and feeding; it has been frequently observed on the coastal strand and ocean at the proposed LNG site. It is also a rare visitor to the San Joaquin Valley wetlands (California Department of Fish and Game, At the Crossroads, 1974 and U.S. Bureau of Sports Fisheries).

The sandhill crane is protected by California. It is a winter visitor to marsh, herbland, and cropland areas, mainly in southern San Joaquin Valley. It is protected due to a decline in suitable habitat (Small, 1974).

The California condor, also listed as endangered, nests on rugged isolated cliffs in Santa Barbara, Ventura, and San Luis Obispo Counties, but forages for carrion over extensive areas of southern California, chiefly in the coast ranges. This species is of particular concern because of its greatly reduced population (estimated at 50 to 60 individuals) and restricted breeding range. This condor's population has declined due to human disturbance, habitat loss, and low rate of reproduction. Human activities to within one-half mile of nesting birds may be sufficient to cause nest failure. The nesting sites nearest the proposed pipeline route are approximately 15 miles northwest of milepost 50 of the Point Conception to Arvin route. Condors regularly fly across the area between Twitchell Reservoir and western Cuyama Valley, crossing the proposed route between mileposts 42 to 57. An important feeding area for a small group of condors is the "Spanish Ranch" area about 7 miles southeast of milepost 57 (California Department of Fish and Game, At the Crossroads, 1974; Seymore, undated; Wilbur, 1974; and Abbott, 1973).

The American peregrine falcon, considered endangered, is widely distributed in western North America, but its breeding population is rapidly declining. In 1970, the successful breeding population in California consisted of only two pairs. In California, the peregrine falcon breeds at scattered localities along the coast, on the Channel Islands, and in the higher inland mountains. No breeding localities are known to occur in the vicinity of the proposed route. When not nesting, individuals may appear nearly anywhere in the state, particularly along the coast and inland bodies of water. The primary threats to this species are continued food chain contamination by persistent pesticides, illegal taking by falconers, human disturbance, and occasional shooting (California Department of Fish and Game, At the Crossroads, 1974 and Thomas, 1974).

The southern bald eagle is also listed as endangered by the USDI and the State of California. This animal breeds at many localities in the United States, but its numbers are declining. It formerly nested along the coast and the Channel Islands, but present nesting in California is limited to the high mountains of northern California. Individuals range widely and may occur nearly anywhere in the state, particularly along the coast and inland bodies of water. Primary threats to the species are illegal shooting, human disturbance of nesting and feeding areas, powerline electrocution, and food chain contamination by persistent pesticides (California Department of Fish and Game, At the Crossroads, 1974).

The white-tailed kite is protected by California. It is a non-migratory hawk-like bird found only in California and the lower tip of Texas in the United States. It is an inhabitant of woodland, herbland and cropland along the proposed route. It could hunt for food in the herblands and nest in the riparian woodland on the proposed LNG site. After a considerable decline the white-tailed kite population has been increasing in recent years by adapting to feeding in irrigated farmland (California Department of Fish and Game, At the Crossroads, 1974 and Small, 1974).

The blunt-nosed leopard lizard is regarded as endangered. It originally occurred throughout most of the San Joaquin Valley from San Joaquin County southward, but the large irrigated agricultural development of the valley as well as subdivision development has reduced its present distribution to scattered undeveloped locations in the valley, the Carrizo Plain, and adjacent foothills. The proposed pipeline would pass through these areas from mileposts 68 to 86, 89 to 94, and 100 to 118 of the Point

Conception to Arvin segment, and mileposts 0 to 8 of the Arvin to Cajon segment. Its habitat will continue to decrease as more water is imported. One of the last remaining areas of good leopard lizard habitat, the Elk Hills Naval Petroleum Reserve, is scheduled for development for oil production, which could mean a loss of even more habitat. The blunt-nosed leopard lizard inhabits sparsely vegetated plains, alkali flats, low foothills, short grasslands, canyon floors, large washes, and arroyos, but is absent or scarce in heavy vegetation or tall grass. It feeds on large insects and small lizards and uses small shrubs and rodent burrows for cover (California Department of Fish and Game, At the Crossroads, 1974 and Montanucci, 1963).

The desert tortoise is protected by the State of California because increased recreational and agricultural use of its western desert habitat has resulted in a severe decline in population size. The proposed pipeline would pass through the extreme western portion of the tortoise distribution. The tortoise can be found in some of the most severe parts of the desert; it often occurs on washes and flats. This species is diurnal in spring and fall, but is nocturnal during the hot summer months. Eggs are laid in shallow burrows usually in June, with hatching occurring about 3 or 4 months later (Stebbins, 1954 and Woodward-Envicon, Inc., 1974).

The southwestern toad is protected by California and could occur along streams, especially in dry arroyos where the streams are intermittent near the proposed pipeline and LNG terminal. The breeding season is from March to early June.

The red-legged frog, also protected, can be found near permanent ponds, and marshes near the proposed pipeline in the San Joaquin Valley. This frog breeds generally in January and February in the project area.

The Tehachapi slender salamander is classified as rare by the State of California. It is a recently discovered species which presently is known only in five small localities in the Piute and Tehachapi Mountains. The locality nearest the pipeline route is approximately 5 miles north of milepost 18 (Brame, 1968). This animal lives primarily in foothill woodland and riparian vegetation under rocks and logs, or underground in animal burrows. The distribution of this species may extend into the area of the proposed route. Similar habitat would be traversed around milepost 10 and would be barely missed near mileposts 18 and 19 (California Department of Fish and Game, At the Crossroads, 1974).

The ensatina, protected by California, could occasionally be found in oak woodland along the proposed route especially in the Transverse Ranges Province. It avoids steep slopes and occurs where there is much surface litter (Stebbins, 1954).

Although not yet currently listed as rare, endangered, or protected by either the State of California or the USDI, the prairie falcon should be noted here. Its declining population is presently being studied by the USDI. It breeds over much of western North America and in California particularly in arid open terrain along the inner coast ranges. It may occur nearly anywhere along the proposed pipeline route but is most common inland of the Caliente Range. The primary cause of the population decline of this species is believed to be pesticide contamination and human disturbance. They tolerate almost no disturbance within their nesting range. The proposed route would not cross any cliff faces, which are potential nesting sites for the prairie falcon. However, sandstone cliffs to over 50 feet high do occur adjacent to the route in the Sierra Madre Mountains near the Cuyama River crossing. Several known prairie falcon nests occur between mileposts 50 and 65 of the Point Conception to Arvin route. Several potential cliff nesting localities occur near Adobe Mountain and Shadow Mountain, near milepost 76 and milepost 85, respectively, of the Arvin to Cajon route; the proposed route would come to nearly one-eighth mile of these cliff faces (Grinnell and Miller, 1944; Thomas, 1974).

Socioeconomic Considerations

Regasification Plant Site Vicinity--The proposed regasification plant site is situated on a narrow coastal terrace at the foot of the Santa Ynez Mountains in southwestern Santa Barbara County.

The socioeconomic trends of Santa Barbara County have closely paralleled historical land use patterns. During the early 1800's, the local economy and trade centered on agriculture, livestock production, and occasional trade with Spanish, Mexican, and American ships passing through the area. American acquisition of California substantially increased the rate of settlement in the county and resulted in more intensive agricultural and livestock development. The late 1800's and early 1900's saw the first concerted explorations of the county's various mineral resources and associated change in the area's economy, but the rate of population growth remained relatively low in comparison to the rest of California. Even with active oil production in the 1930's, the local economy and population remained stable until after World War II. However, in the late 1940's, with the development of new water supplies, location of a new University of California campus in Goleta, and the establishment of Vandenberg Air Force Base to the north of Point Conception, an unexpected high growth rate for Santa Barbara County occurred. Research and development, and electrical component industries were attracted by the university and military base. These industries settled in the Goleta, Lompoc, and Santa Maria areas bringing in new working populations which consequently increased the demand for housing.

In terms of population and density, Santa Barbara County ranks near the middle of California's 58 counties. According to the 1970 census, the county has 264,324 inhabitants and a population density of 96.6 people per square mile. However, the growth rate for the county as a whole, between the 1960 and 1970 census, was more than twice the state growth rate (56.4 percent as compared to 27 percent).

A breakdown of county growth statistics reveals that the most active area is Goleta Valley, which extends from the eastern boundaries of Goleta west to Gaviota. The only population centers within 15 miles of the proposed site are Gaviota with a population of about 80 and the city of Lompoc, with a population of 25,284. The largest city within 50 miles is Santa Barbara (70,215). However, the urban concentration, which consists of Santa Barbara and surrounding urbanized areas (primarily Goleta), has a population in excess of 100,000. Population projections prepared by the Santa Barbara County Planning Department indicate that the general county is expected to continue to grow at a slower rate of roughly 10 percent per decade, attaining an estimated population of 350,000 by 1985. However, the Goleta-Goleta Valley area is expected to grow at a slightly faster rate of 18 to 19 percent per decade. If these projections are accurate, nearly 46 percent of the county's cumulative growth by 1985 will take place in the Goleta-Goleta Valley environs.

Within the immediate site vicinity, the population distribution is minimal, averaging one person per square mile within a 10-mile radius of the site. Very little residential development presently exists in the local area. Approximately 10 residences occur within 2 miles of the proposed site, most of which occur on the Hollister Ranch to the north and east.

Several residences occur in and around Point Conception, which is 3 miles west of the proposed site.

The Hollister Ranch is the most significant local entity in terms of land acreage and potential future development. The 135 parcels (each a minimum of 100 acres) are being sold as exclusive home sites. No population projections exist for the specific site area.

The principal components of Santa Barbara County's local economy today are agriculture, construction, mineral production, tourism, and government.

Agriculture is one of the major economic activities. Gross farm income for 1972 totalled an all time high of $115.2 million, which is an increase of nearly $6.5 million or 6 percent above the 1971 level. Agricultural production in 1973 amounted to over $152 million, a 32 percent increase over 1972.

Vegetables, valued at nearly $40.9 million in 1972 were the county's major agricultural crop, contributing approximately 35 percent to the county's gross value of agriculture production. Broccoli, lettuce, and celery, which are the leading vegetable crops, accounted for approximately $26.2 million, some 64 percent of the 1972 total vegetable crop valuation.

The fruit and nut crop, valued at $20.6 million, was the county's second major agricultural category in 1972, followed by livestock and poultry valued at $20.3 million. Major products of the fruit category are lemons, strawberries, and avocados.

In 1973, construction activity accounted for over $104 million, an increase of over 10 percent over 1972 activity. Residential construction accounted for over 80 percent of the total which may be indicative of the current and future population growth within the county.

The 1970 value of mineral production in Santa Barbara County totalled $104.9 million. Of this total, petroleum production accounted for $52 million, natural gas for $20.1 million, natural gas liquids for $6.4 million, sand and gravel for $1.5 million, and diatomaceous earth, lime, mercury, phosphate rock, and stone combined accounted for $24.8 million. Santa Barbara is one of the leading mineral producing counties in California.

The net income from tourism within the county is also substantial and can be expected to increase. In 1971, tourism provided $36.6 million in general expenditures in the prime Santa Barbara tourist areas. In 1973, expenditures amounted to over $60 million for approximately 4.3 million visitor days.

The effect of Vandenberg Air Force Base on the county's economy has been very significant. This missile base is located approximately 10 miles northwest of the proposed plant site and is Santa Barbara County's major federal employer. Within 2 years following the Federal government's decision in 1957 to construct and operate these facilities, the base was first in importance in the county's economic structure.

Currently, the estimated base work force is 11,000 persons, of whom 50 percent are military personnel and 50 percent are civil service employees of the military. Annual payrolls amount to approximately $72 million. Payments made to 11,000 retired military and civil service personnel residing in the area amounts to $45 million annually. The Lompoc and Santa Maria-Orcutt areas have and should continue to benefit from a great deal of the economic activities and associated services and industries supporting Vandenberg Air Force Base.

Retail establishments should be considered yet another active economic force which has a significant impact in Santa Barbara County. In 1971, retail trade employed 16,106 persons with a taxable payroll of $18.4 million. Preliminary estimates place Santa Barbara County's taxable retail sales at nearly $701 million in 1973. General manufacturing employed 10,472 persons in 1971, with a taxable payroll of $22.7 million. Real estate and land speculation have historically been active throughout the Santa Barbara area. Within the last two decades, acquisition of land for residential and industrial development has become the major focus of the real estate market.

Santa Barbara County does not produce all the goods and services necessary to sustain the resident population. It is necessary therefore, to import goods and services from outside the county. To pay for these items, a number of basic economic forces within the county stimulate local export activity and cause a flow of income from outside back into the communities of the county. The net value of export income, therefore, has a substantial bearing on the value of goods and services imported, on all economic activity within the county, and ultimately on the dependent population.

Categorical employment in Santa Barbara County is relatively diversified with no one occupation accounting for more than 20.1 percent of the total labor force. The total resident civilian labor force in June 1974 was 118,000 persons. Approximately 6,900 persons were listed in the unemployed category which resulted in a seasonally adjusted unemployment rate of 5 percent. The U.S. Department of Labor classified the county as an "area of moderate unemployment." Table 8.2.1.-40 shows a breakdown of employment by industry for 1974.

The construction labor force within the county, as a percentage of total employment and population, has been diminishing for about 10 years. Construction of Vandenberg Air Force Base in the early 1960's increased construction employment to its peak of 6,400 persons. Since 1970, construction employment has never exceeded 3,600 persons (on an annual average basis). Currently, there are 500 skilled and unskilled workers from Santa Barbara County, principally electricians and pipefitters, who are employed at the Diablo Canyon power plant construction project in San Luis Obispo County. The addition of these 500 workers to the current construction labor force employed in Santa Barbara County gives a total pool of 4,100 construction contract workers for 1974.

Total non-agricultural wage and salary employment rose less than seasonally to 93,400 in May 1975 from 93,000 in April 1975. The food processing industry showed the largest month-to-month employment gain reflecting a seasonal pickup in canning and preserving activities while construction continued with a modest spring upturn. The only other significant employment gain occurred in government as the county added approximately 100 workers. The overall increase in May 1975, however, was moderate. The annual growth rate in wage and salary employment over the May 1974-May 1975 span was only 4 percent, the lowest in nearly 4 years.

Total personal income of Santa Barbara residents has increased 37 percent between 1969 and 1973, reflecting an average annual rate increase of 9.3 percent. The county's total personal income is estimated at $1,389 million for 1973. On a per capita basis, 1973 personal income was approximately $5,034, up 8.6 percent from 1972's per capita income. Historical personal income data is presented in Table 8.2.1.-41.

Table 8.2.1-40 Santa Barbara county labor force - June 1974

Total Civilian Labor Force[1]		118,000 (100%)
Unemployed		6,900 (5.8%)
Employed[2]		111,100 (94.2%)
Nonagricultural Wage and Salary Employment[3]		92,700 (78.6%)
Mining	700 (0.6%)	
Construction	3,600 (3.1%)	
Manufacturing	12,000 (10.2%)	
Transportation, Communications, and Utilities	3,300 (2.8%)	
Wholesale and Retail Trade	22,100 (18.7%)	
Finance, Insurance, and Real Estate	4,300 (3.6%)	
Services	23,700 (20.1%)	
Government	23,000 (19.5%)	
Agriculture		6,600 (5.6%)

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[1] Total labor force by place of residence and including workers involved in trade disputes.

[2] Includes self-employed, unpaid family, and domestic workers.

[3] Employment by place of work excluding workers involved in labor disputes.

Source: Federal Power Commission, 1975, Vol. III

Table 8.2.1-41 History of personal income - Santa Barbara county vs. California

	1966	1967	1968	1969	1970	1971	1972	1973	% Increase 1966 to 1973
SANTA BARBARA COUNTY									
Aggregate Personal Income ($ million)	810.4	876.4	950.3	1.013.9	1,092.7	1,160.4	1,264.0	1,389.0[1]	71.4
Per Capita Personal Income ($ million)	3,248	3,461	3,711	3,849	4,134	4,299	4,635	5,034	55.0
STATE OF CALIFORNIA									
Aggregate Personal Income ($ million)	65,156	69,936	76,901	83,192	89,312	94,412	102,100	112,100	72.0
Per Capita Personal Income ($ million)	3,451	NA	NA	NA	4,460	4,654	4,976	5,405	56.6

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[1] 1973 estimate

Source: Federal Power Commission, 1975, Vol. III

The largest local source of revenue for Santa Barbara County is property tax. In 1971, the net taxable assessed valuation for land in the county amounted to $690.4 million. The average tax rate per $100 of assessed valuation in the county was $11.79. The total rate in the specific area of the proposed LNG site, however, is $8.9303 per $100 of assessed valuation. The assessed value of the property owned by SCE is $500 per acre, as determined by the California State Board of Equalization. Thus, the 1,000 acre unimproved site at present yields approximately $45,000 annually in property tax revenue.

The economic trends of Santa Barbara County and the south coast in particular are closely associated with land use. Population growth is indirectly governed by the same plans, restrictions, and potential problems which occur with land use. Agriculture, which historically has been a prime land use of the county, has been gradually declining in the south coast economy. Conversion of agricultural land to residential and light manufacturing zones surrounding urban centers has been a main cause of the past decline. Unless agricultural production is maximinized, the economic pressures for conversion to other uses will further decrease the importance of agriculture within the county.

Projected expansion of the University of California (Santa Barbara) and decreased military activity at Vandenberg Air Force Base will affect the research and development industries and services that depend on them. The growing southern California population levels have increased recreational activities and tourism. These forces will continue to play an important role in the county economy.

Industrial expansion and changes in the county industrial profile could change significantly. Further industrial expansion will be greatly influenced by the availability of land and the compatibility of major industrial development with critical environmental issues. Tremendous effort has been applied to implementing land use policies which would coordinate complex relationships between land, people, and facilities to preserve the environmental quality of Santa Barbara County as well as protecting human health, safety, and welfare. The previous moratorium on new offshore petroleum production which resulted from the 1969 oil spill reduced the total county value of petroleum production. Recent sales of new Federal offshore leases when combined with the State of California's decision to relax their restrictions on development and Santa Barbara County's approval of Exxon's onshore facilities, could encourage new petroleum activities. The pace and integration of population growth and new industrial and commercial development will be dependent upon economic and land use policies formulated by the state and county, which would set the direction for growth and change. However, a new bill, which was recently passed in the California State Legislature (Assembly Bill No. 180) may curtail such rapid expansion. This bill would prohibit any person to construct, expand, place, or locate any oil or gas pipeline or associated facilities for the transportation of oil or gas from an offshore oil or gas extraction operation on or across tidelands or submerged lands within the permit area of the coastal zone (generally defined as the area lying between the seaward limit of the states jurisdiction and 1,000 yards landward from the mean high tide line), unless the project has previously been permitted or exempted by a regional coastal zone conservation commission and, if appealed, by the California Coastal Zone Conservation Commission previous to the enactment of the bill, until either implementation by the legislature of the Coastal Zone Conservation Plan or December 31, 1977, whichever occurs first.

The California Legislature has enacted this bill on the basis that the need to develop petroleum on outer continental shelf lands off the coast of

California, and the need for additional development on state offshore lands has not been demonstrated by reliable and independent data. Further problems which have compounded this situation include private and public activities which may create a potential net surplus situation in California if outer continental shelf, state offshore, and Alaskan production of petroleum products are not developed in proper sequence. In addition, it was declared that the plans of certain private corporations which would apparently continue petroleum and petroleum product importation, by construction of major facilities to receive very large crude carriers of a size not required for domestic transshipment, is also a major compounding factor. This bill would not affect the development of Western's LNG facility.

Heavy industrial development has not been attractive in Santa Barbara County, but current trends which would increase county unemployment could significantly affect county policy concerning development and possibly attract new industry in search of a work force.

Pipeline Routes--

San Luis Obispo County--The economic base of San Luis Obispo County is heavily dependent on the government, trade, and services sectors. Agriculture also plays an important role but it is not as significant as in Santa Barbara or Kern Counties. Government accounts for over 32 percent of the county's total resident employment and will probably continue as a growth leader. However, manufacturing comprises only 5.5 percent of the total employment. Transportation cost disadvantages may preclude extensive development of manufacturing. The wholesale and retail trade category is expected to increase due partly to local efforts which are being directed towards promoting the county as a regional trade center and towards increased recreational activities.

San Luis Obispo County has two distinct climatic zones (coastal and inland) which have influenced economic development, particularly in the recreational and agricultural sectors. The Pacific coastline provides the focal point of many of the recreation and tourist attractions and related services. The inland area accounts for lands with high agricultural productivity and the mountainous regions favor grazing activity.

Total agricultural output jumped to a record level in 1973. The $82.6 million in valuation was more than 27 percent above 1972's production. In 1973, 16 individual crops posted valuation over $1 million each. The three major agricultural products were cattle and calves, lettuce, and celery.

San Luis Obispo County was first in construction activity in 1972, accounting for $100 million, as compared to Santa Barbara County which accounted for $95.1 million in the same year. However, the 1973 estimates show a decline, in both counties, for nonresidential construction activities. In San Luis Obispo County, nonresidential building accounted for less than 14 percent of the total 1973 valuation. In Santa Barbara County, nonresidential construction in 1973 dropped 7 percent to $20.4 million from the 1972 total of $21.9 million.

The population of San Luis Obispo County in July 1974 was estimated to be 128,888 residents. Most of the residents live along the coastal region with an urban population near 60 percent. The largest cities are San Luis Obispo, the county seat (31,900), Arroyo Grande (8,225), Morro Bay (7,875), and Paso Robles (7,550).

The county had a higher growth rate than the state average between 1960 and 1970. Since 1970, the population growth rates have continued to exceed the state average. From 1970 to 1973, the county's population increase was 10.9 percent greater than that of California.

The total resident civilian labor force has approached 44,100 of which 2,350 are unemployed. The unemployed account for 4.4 percent on a seasonally adjusted basis. This rate is unusually low for an agricultural area and may be an indication of the relatively minor role played by seasonal agriculture in the county's economy.

Kern County--The economy of Kern County will probably not change appreciably from a predominantly agricultural and petroleum production base. However, a slow evolution is taking place with one segment of the economy advancing as another one declines. At the present time, the number of persons employed in non-agricultural jobs is increasing at a faster rate than for agriculture jobs with wholesale and retail trade, government, and services recording the largest numerical and percentage gains. While the manufacturing and other nonagricultural activities increase in importance, it is not expected to do so at the expense of agriculture. Kern County has been included among the top five counties in the nation in total farm production for over 20 years and there is no evidence which suggests any change in this status.

The population in Kern County continued to increase during 1974, the provisional mid-year total being 341,300 persons. This figure represents a 0.3 percent gain from the 1973 revised total of 340,400 and was 3.1 percent above that recorded by the 1970 census. The population is 40 percent urbanized, with 22 percent of the population living in Bakersfield (76,200), the largest city and county seat. Next ranking cities are Delano (15,200) and Ridgecrest (13,050). Ridgecrest is one of the fastest growing cities in the county.

Moderate population growth is projected in Kern County for the remainder of the century and should occur at a rate lower than the state in general. Bakersfield and other established communities would expand as a result of population growth in the area. Only minor growth is expected in areas near the proposed pipeline route. Several resort-type communities such as Stallion Springs have already been subdivided and partially developed in the region. In the past such attempts have proven unsuccessful but should these developments succeed, others are likely to follow.

Since Kern County is one of the richest agricultural areas in the world, stable economic growth is projected for the future. In 1973, agricultural production amounted to $598 million, a 34 percent increase over the previous year. For the same year, 809,578 acres were under harvest. Predictions indicate that approximately 1.1 million acres of land would be under cultivation by 1980, largely due to the availability of water from the California State Water Project. In addition, gains in yield per acre are maximizing due to improved methods, plant varieties, new harvesting techniques, and more sophisticated management.

In the past, the value of mineral production exceeded agricultural production. However, with continued growth in agriculture, this trend is expected to reverse itself as mineral production stabilizes.

Two military installations, Edwards Air Force Base and the Naval Weapons Center at China Lake, account for approximately 83 percent of all federal jobs in the county. Total civilian employment reached 130,500 persons in 1973, a 1.5 percent increase above the level registered in 1972.

In 1973, the county's unemployment rate dropped to 5.2 percent from 5.8 percent in 1972. The civilian labor force is anticipated to include 151,000 persons by 1980, with government remaining a relatively large employment group.

Los Angeles County--Initial settlements in the northern region of Los Angeles County were concentrated in the Newhall-Saugus area and along the southern rim of the Antelope Valley. Until the late 1800's Antelope Valley, which is geographically a part of the Mojave Desert, was sparsely populated. The opening of the Southern Pacific Railroad line in 1876 from San Francisco to Los Angeles drew additional settlers to the area. Even then, the area was primarily used for cattle raising because of a lack of available water.

Mining played a significant role in attracting settlers to the area. The first discovery of gold in commercial quantities in California took place in Placerita Canyon in 1842. In addition, California's first commercially productive oil well began producing near Newhall in 1875.

The introduction of the railroad and commercial farming were key innovations which stimulated population growth in the area. The new transportation and farming economy supported a much denser population and permitted the widespread development of many small towns and cities. With the onset of World War I, industrialization within the coastal lowlands upsurged. The population density increased to a level far greater than contemplated. Urban growth temporarily subsided during the great depression of the 1930's only to be stimulated by World War II with unprecedented growth and change.

Today the entire county of Los Angeles has a widely diversified economic base. Manufacturing, retail and wholesale trade, and the service industries represent the major employment categories and revenue generators. Agriculture is relatively insignificant in Los Angeles County as compared to Kern and San Bernardino Counties. Over the years, the county's economic base has shifted from agriculture to petroleum to aerospace.

The county accounts for approximately one-third of the state's population, personal income, employment, retail sales, and automobile sales. The port facilities at Los Angeles (city) and Long Beach handle over one-half of California's international trade.

The population of Los Angeles County was estimated at 7,034,000 in January 1974. This represents a population loss of approximately 8,000 from the 1970 census figure of 7,041,980, primarily because of emigration to surrounding counties. A substantially slow population growth is now expected for Los Angeles County. By the year 2000, the county's population should reach 7,850,000. In northern Los Angeles County, very little population growth is expected near the proposed pipeline route. A substantial amount of urbanization is currently occurring in the Antelope Valley communities of Lancaster and Palmdase to the southwest of the proposed route, but population growth in the desolate northeastern corner of the valley is unlikely.

Despite both a national climate of economic uncertainty and recent declines in the county's population, the Los Angeles County labor force has continued to expand. In May 1974, there were 3,175,900 persons in this labor force, which represents a gain of 2.3 percent from the May 1973 level.

Manufacturing accounts for more than one-fourth of total employment in Los Angeles. An estimated 831,300 persons were employed in that economic sector in May 1974. Employment in aerospace, the largest manufacturing category, has recovered some since 1971, and was estimated at 257,000 in May 1974.

Second in importance is the wholesale and retail trade category, which employed 698,100 persons in May 1974. The service industries were third in importance.

In May 1974, approximately 212,800 of the total civilian labor force of 3,175,900 were unemployed. This reflects a seasonally adjusted rate of 7 percent unemployment. Los Angeles County is classified by the U.S. Department of Labor as an "area with substantial unemployment."

San Bernardino County--During the latter decades of the 19th century, promoters and developers discovered and exploited rich mineral deposits in many mining districts of San Bernardino County. Although most of these mines have long since been abandoned, limestone and saline resources are still actively refined and marketed.

During the pioneering phase of the mining boom, thousands of migrants entered the area of San Bernardino County. Later, productive mining activity attracted permanent populations of miners and people with supportive services. Railroads were constructed to serve the growing populations and their economy and many homesteads were established. Cattle ranching and hay production were the principal agricultural activities.

Prior to World War II, most communities were concentrated near the water source of the Mojave River. Other scattered communities were dependent upon limited water resources. During World War II the region was utilized to train military personnel. Temporary camps were established and the military payroll began to create many new jobs thus providing support for additional workers and dependent families.

Since the war years, the region has gradually established a stable economy for growth. The railroad and highway systems continue to be generators of new money to the area. Mineral and agricultural products are still of primary importance. Defense training and testing activities with their attendant military and civilian payrolls also continue to be influential growth factors.

Between the 1960 and 1970 census period, the county population increased from 503,591 to 684,072. Projections from the State Department of Finance suggest that the county's population will total 711,000 in 1975 and 765,100 by 1980. The major population centers have been concentrated south of the San Gabriel and San Bernardino Mountains in the northeastern end of the Los Angeles Basin, and this area contains 80 percent of the county's population. This southwestern portion of the county would be the most probable location of expanded growth. The major desert regions of the county should experience a moderate growth rate. There are current trends towards development in some of the high desert areas such as Adelanto, Victorville, Apple and Lucerne Valley and Hesperia to meet the residential and recreation needs of the populace from the nearby Los Angeles Metropolitan areas.

Most industrial activities are located in the highly urbanized areas of San Bernardino and Pomona Valleys and are very limited in the Mojave Desert region. The leading employment category is government followed by retail and wholesale trade. The service industries are ranked as the third largest employment group.

In December 1974, the available labor force in the Riverside-San Bernardino-Ontario labor market was 502,700. The seasonally adjusted unemployment rate was 10 percent.

Land Use and Recreation

Regasification Plant Site Vicinity--During the last several centuries, there have been a succession of cultures and land uses in Santa Barbara County. The grazing and agricultural land use patterns that strongly prevailed for at least 200 years were initiated when the Spanish colonization of the area displaced the native Indian cultures. The land was usually divided into large family land grants or rancheros. The American acquisition of California had little initial effect on land use other than to break up a few of these land grants. The intensive development which proceeded in other portions of California, was retarded by the tenure of these large land grants.

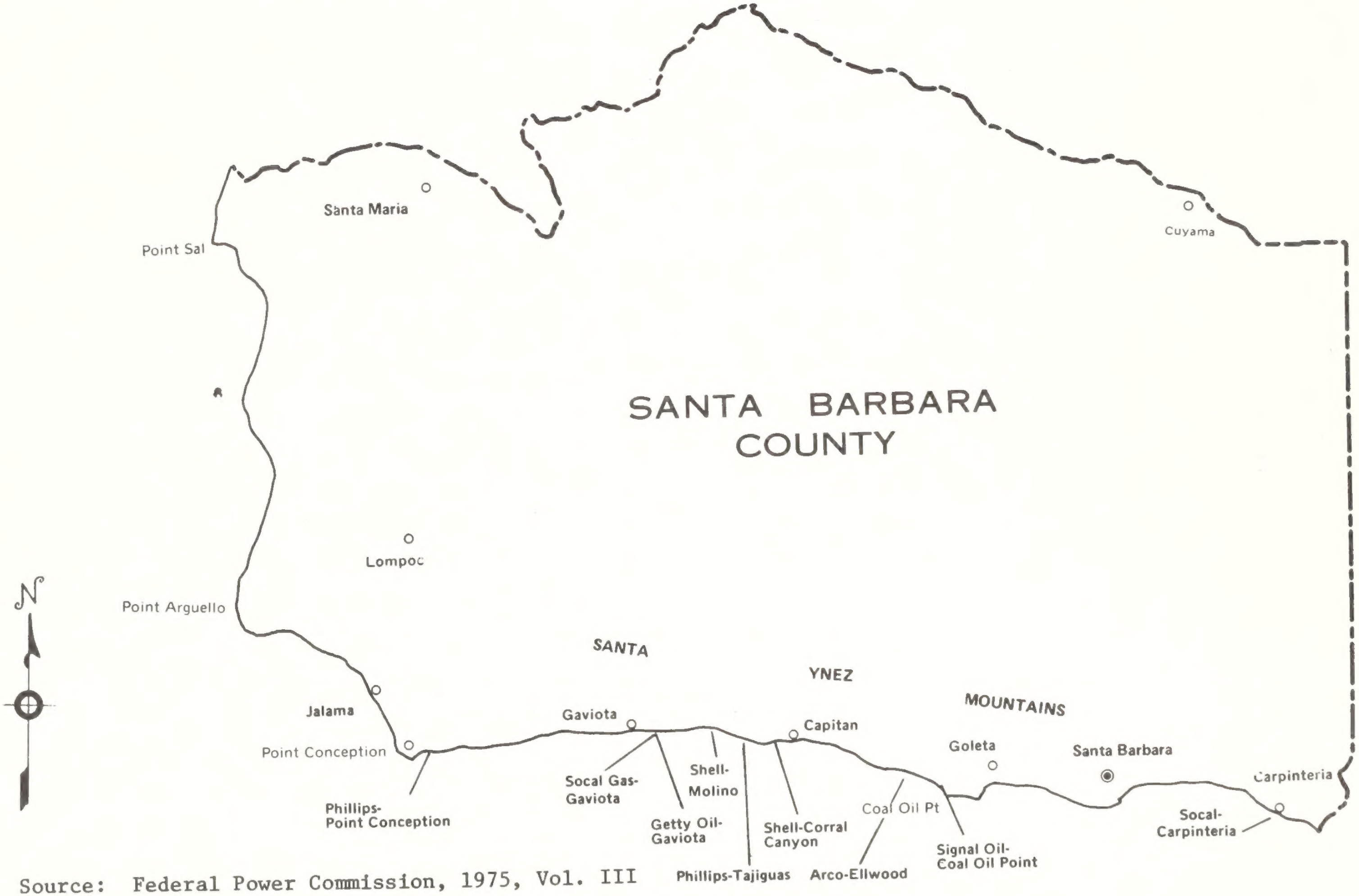
During this time, Santa Barbara was serving as one of the principal trade centers on the California coast. Grazing was still the prevailing land use even though commercial agriculture was becoming increasingly important, particularly in the northern part of the county. The county continued to remain relatively undeveloped because of its inability to compete with other commercial agriculture and livestock centers in the state.

Intensive industry began to develop in 1928 after the discovery of petroleum off the coast of Goleta, which is located approximately 10 miles west of the city of Santa Barbara. This industry was held to a minimum, due to the lack of offshore drilling technology. Most of the coastal plain continued to be used as grazing land, or for citrus and avocado orchards. The city of Santa Barbara remained a small commercial center of population. The establishment of Los Padres National Forest acted as a major restriction on land use development because it removed 628,776 acres of county land from private ownership.

Santa Barbara continued as a predominantly rural county through the early 1960's because of its geographical isolation, while other southern California areas were rapidly urbanizing. Santa Barbara began to experience the growth pressures that had been affecting other areas throughout the state with the establishment of several research oriented businesses and light manufacturing firms. The expansion of the University of California at Santa Barbara (UCSB) also gave impetus to the rapid suburban development of Goleta. Land previously used for agricultural activities was converted to commercial and residential development.

The primary obstacle to growth in this area was an inadequate water supply accompanied by a receding water table. This problem was temporarily circumvented by the construction of Cachuma Dam and the associated water pipelines. The rate of population growth rapidly accelerated with this new supply of water. However, an adequate water supply still remains a critical factor in the future development of the area in light of increasing growth pressures.

With the advent of feasible offshore drilling technology, development of petroleum resources and treatment facilities began along the entire Santa Barbara coast. Currently, there are nine petroleum product treatment facilities on the south coast between Point Conception and Carpinteria (see Figure 8.2.1.-36). Current land use development focuses on the potential of offshore drilling and prospective plans to locate new industry in the county.



Source: Federal Power Commission, 1975, Vol. III

Figure 8.2.1-36 Existing oil and gas facilities in Santa Barbara county

There are many historical sites and monuments as well as many scenic areas in all parts of the county which constitute a significant resource. These sites are attractive and provide a well founded base for the tourist industry which is centered around the city of Santa Barbara.

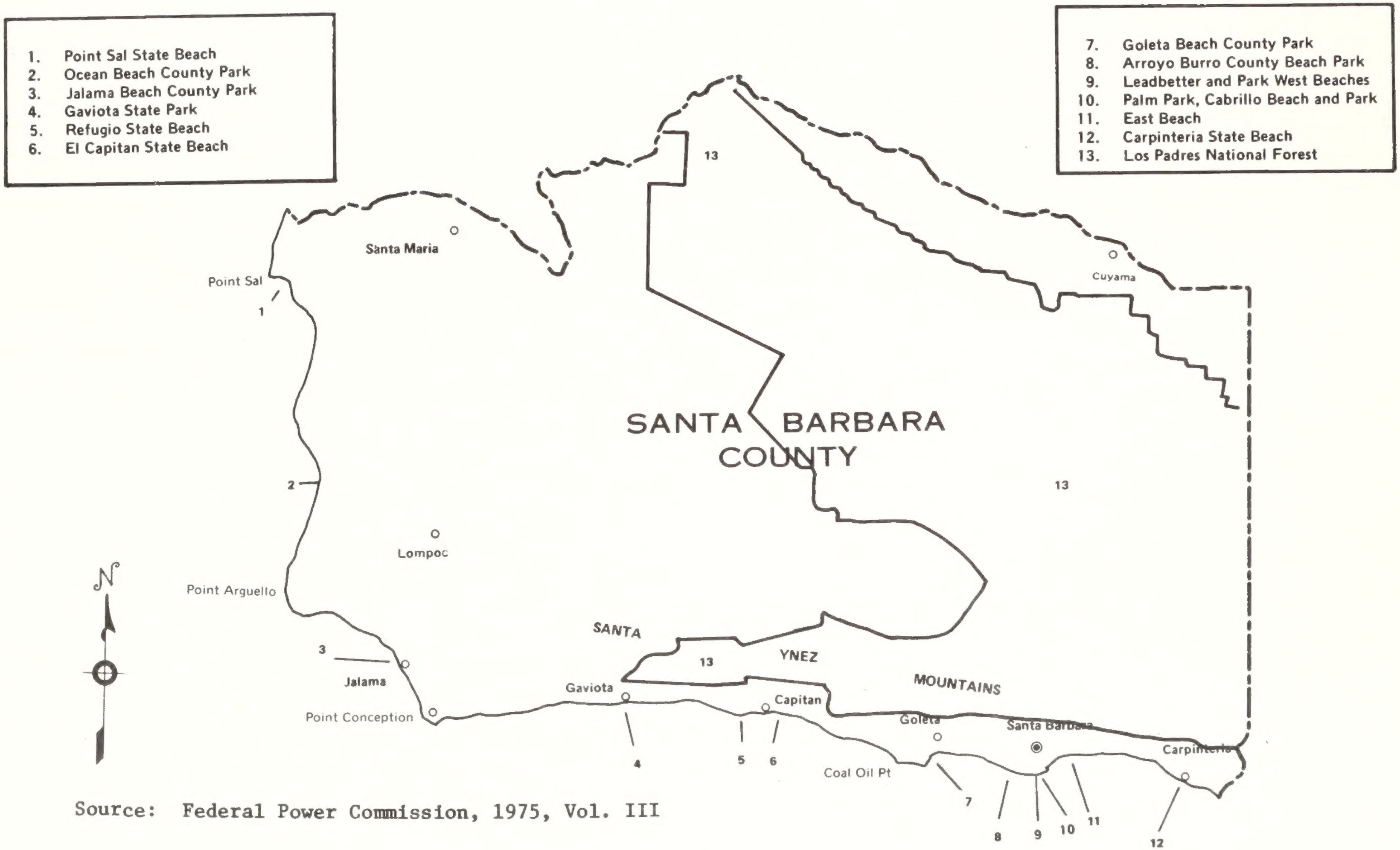
The growing tourist trade introduced new people to the county. This in turn increased the immigration rate into the county and investment in real estate along the coastal plain.

Aside from the research oriented industries in the county, the extraction and processing of mineral resources other than petroleum plays a vital role in the local economy. Construction quality sandstone is quarried in some areas of the county and pure diatomaceous earth is mined near Lompoc. A considerable amount of sand and gravel is obtained from the Santa Ynez and Santa Maria Rivers. Several citrus processing and light manufacturing plants are located primarily in the Santa Barbara, Goleta, and Santa Maria areas. Vegetables, citrus fruits, field crops, and nursery products are grown on a large commercial scale in the southeastern and northwestern portions of the county.

In addition to the land-based agricultural activities, the marine resources of the Santa Barbara Channel provide a significant amount of food resource. The Port of Santa Barbara is the state's fourth most productive fishing port. In 1970, the port accounted for approximately 6 percent of California's fish catch. Giant kelp is harvested commercially from offshore beds for use in food processing, plastics, and other industries. Harvesting occurs throughout the year with specially equipped trawlers which travel along the coast cutting kelp at the surface. The Santa Barbara Channel supplies approximately 40 percent of the annual California harvest.

High density residential tracts are found in three sections of the county. They include the south coast region (Goleta east to Carpinteria), the west coast region (area which includes Vandenberg Air Force Base and Lompoc), and the northwest region (Santa Maria-Orcutt area). Goleta Valley is the fastest growing region of these areas. The population in this area is projected to increase by two-thirds by 1985. Vandenberg Air Force Base, located approximately 10 miles north of the proposed project site, places housing and service demands on the local area. Vandenberg conversely supports commercial and industrial activities related to or serving the base. Residential development will spur the conversion of prime agricultural lands to urban needs.

Recreational and open space lands represent a substantial portion of the county's land area. Los Padres National Forest extends over 628,776 acres of the county's 1,775,360 total acres. This preserve encompasses most of the coastal Santa Ynez Mountain Range and the rugged interior ranges. Hunting, fishing, hiking, horseback riding, camping, and off-road vehicle recreation are associated with the national forest. Another federally administered recreation area is the Channel Islands National Monument. The monument, which contains two of the five Channel Islands, Anacapa and Santa Barbara Island, provides facilities for boat landings, hiking, and camping. Similarly, diverse recreational uses occur at the state and county beaches and parks. Many public beaches and campgrounds can be found east of the site, such as Gaviota, Refugio, and El Capitan State Beaches, which are respectively, approximately 11, 19, and 24 miles east of the proposed site. Jalama State Beach is located 6 miles northwest of Point Conception (see Figure 8.2.1.-37). In addition to the public beaches throughout the county, many privately-owned beaches are used for swimming, surfing, and fishing activities by the local residents.


1. Point Sal State Beach
2. Ocean Beach County Park
3. Jalama Beach County Park
4. Gaviota State Park
5. Refugio State Beach
6. El Capitan State Beach
7. Goleta Beach County Park
8. Arroyo Burro County Beach Park
9. Leadbetter and Park West Beaches
10. Palm Park, Cabrillo Beach and Park
11. East Beach
12. Carpinteria State Beach
13. Los Padres National Forest
SANTA BARBARA COUNTY
Santa Maria
Point Sal
Lompoc
Point Arguello
Jalama
Point Conception
Gaviota
Capitan
Coal Oil Pt
Goleta
Santa Barbara
Carpinteria
Cuyama
SANTA YNEZ MOUNTAINS
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Source: **Federal Power Commission, 1975, Vol. III**

Figure 8.2.1-37 Major recreation facilities in Santa Barbara county

The coastal waters from Point Conception east to Gaviota support an extensive fishing and kelp harvesting business and good to excellent surfing conditions occur at several locations. Consequently, these activities represent the significant sport and commercial uses of offshore areas near the proposed site. However, due to restricted public access through the Hollister Ranch which eliminates vehicle traffic to the local beaches, commercial and recreational activities common to more populated and accessible areas of southern California are highly limited in the site vicinity.

Commercial fishing is probably the most intensive offshore use in the immediate area. Commercial divers regularly work the bottom area between Canada del Cojo and Barranca Honda. Nearshore waters support an abundant abalone fishery. Rockfish, bonita, and anchovies are also common in the area. Consequently, gill netters, purse seiners, and trawlers from Santa Barbara, Morro Bay, and other southern California ports occasionally fish the waters off Cojo. In addition, kelp is harvested on a commercial basis year round. Sport (scuba) diving is also popular, as is surfing. All of the prime surfing areas are used by surfers despite vehicle restrictions. The problem of accessibility is partially alleviated by the availability of small boat launching facilities at Gaviota State Beach Park, located approximately 11 miles east of the proposed site.

The proposed plant site is located on a narrow coastal terrace approximately 3.5 miles east of Point Conception. Point Conception is a promontory at which point the north-south coastline turns eastward, forming the Santa Barbara Channel between the mainland and the string of islands approximately 30 miles offshore. Barranca Honda Canyon to the east and Canada del Cojo to the west form natural laterals to the proposed site. The site is in the western portion of a 975-acre area, presently owned by Southern California Edison Company (SCE), which is being reserved for potential industrial use. This 975-acre area of land was purchased by SCE in August 1965 from the Hollister Estate Company. This transaction precluded any involvement with the current Hollister Ranch Corporation.

Most of the land in the vicinity of the proposed project site (and including the site) is zoned 100-AL-O (Limited Agriculture). For the most part, the area is undeveloped and is predominantly utilized for cattle grazing. Agricultural activities are the main land use within a 5-mile radius of the site. There is an unused oil storage tank located approximately 2.3 miles away at Government Point. Automated U.S. Coast Guard facilities are located near Point Conception, approximately 3.1 miles from the proposed site.

The nearest residence to the proposed LNG site is located approximately 4,000 feet to the east. This residence appears to be a small summer cottage which is situated between the Southern Pacific Railroad track and the coastal bluffs. Another small beach cabin is located just to the west of the mouth of Canada del Cojo and 500 feet south of the proposed site. Residences, barns, and sheds exist at the Cojo Ranch, approximately 9,000 feet northwest of the site.

Most of the residential development near the proposed site is located on the Hollister Ranch which is controlled by Hollister Ranch Corporation. The Hollister Ranch is situated to the north and east of the proposed site. In recent years, this large landholding has been divided into 135 parcels, each a minimum of 100 acres. Although these parcels are designated as Agricultural Preserve by the Santa Barbara County Planning Department, the parcels are being sold as home sites for large estates.

As of July 1, 1975, approximately 35 percent of the available parcels on the Hollister Ranch (47 of 135) have been sold to private buyers. Upwards of 20 parcels have either been tentatively sold (awaiting approval of financing or are in escrow). Currently, most of these landholdings are undeveloped. Homes and other improvements have been completed on nine parcels. Over 60 percent of the privately-owned parcels, most of which have homes on them, are located in two of the county assessor's tracts which adjoin the proposed regasification site.

Public access to the Hollister Ranch area is denied to the public by the property owners and the Hollister Ranch Corporation, who hold title to the land as far as the mean high tide line. The area between the mean high tide line and the base of the coastal bluffs is zoned BD (Beach Development). The uses permitted within a BD zone are highly restrictive and according to Ordinance 661 (Santa Barbara County), as amended on July 16, 1973, a BD zone is "designed and intended to preserve and protect a limited natural resource, ocean beaches, which are an important resource in the economy of the county, for the benefit of the general public and of beach and bluff property owners...."

In the 1966 Santa Barbara County General Plan, four potential parks were being considered for public acquisition. These parks would be located within a 5-mile radius of the proposed LNG site. However, according to information from the South Central Coast Regional Commission, no current efforts are being made by the local, state, or Federal agencies to implement the recommendation for the proposed parks. Lack of funding, changing acquisition policies, and potential problems with landowner cooperation were cited as major obstacles. The Open Space and Recreation elements of the County Comprehensive Plan (published in November 1974 and December 1974, respectively) both recommend continued low intensity use and public access restrictions for the Point Conception area.

The four most heavily used modes of transportation in Santa Barbara County are automobile, airplane, ship, and train. The Santa Barbara County airport handles most of the commercial and private air traffic in the county and is located in Goleta. Small airports are found in the communities of Santa Maria, Lompoc, and Cuyama. A small unpaved private airstrip is located approximately one-half mile east from the proposed site. Vandenberg Air Force Base is the center for a substantial amount of military air traffic.

The Santa Barbara Channel is heavily used by both private and commercial vessels. The principal south coast marinas in the county are located in Santa Barbara and Carpinteria.

The principal highway through the county is U.S. Highway 101, a multiple lane highway which is one of the major north-south transportation routes for California. The highway is located approximately 10 miles east of the proposed site at its closest point near Gaviota. California Highway 1, which runs north-south between U.S. Highway 101 and the coast, is separated from the proposed site by a range of the Santa Ynez Mountains and a distance of at least 5 miles. Other roads in the site vicinity are the Jalama Road which provides access from Highway 1 to Jalama State Beach Park and a private unnamed road through Hollister Ranch to the west.

The only rail facility in the area is a mainline track owned by Southern Pacific Railroad. This track parallels the coast and runs through the site between the beach cliffs and the proposed location of the tanks.

Pipeline Routes--General land use patterns found along the proposed pipeline routes are discussed in the following section. The first segment of the proposed route would extend for 142.3 miles from the Point Conception LNG facility site to the Arvin metering station and would traverse portions of Santa Barbara, San Luis Obispo, and Kern Counties. The second segment would extend for 108.9 miles from the Arvin Pressure Limiting Station to the Cajon Metering Station and would traverse portions of Kern, Los Angeles, and San Bernardino Counties.

Beginning at the proposed LNG site in Santa Barbara County, the first segment of pipeline would travel eastward following the coastline for approximately 6.5 miles. Near MP 4.3, the route would pass approximately one-half mile south of the Santa Anita Ranch. The route would be aligned parallel to the Southern Pacific Railroad track which is located approximately 0.25 to 0.5 miles to the south for a distance of 4.8 miles. This is the only railroad facility which would be encountered by the Point Conception to Arvin segment of the proposed pipeline route.

Near MP 6.5 the route turns abruptly northward and crosses the Santa Ynez Mountain Range between MP 6.5 and MP 13. For approximately 4 miles from MP 18 the pipeline route would closely parallel Drum Canyon Road. The unincorporated community of Los Alamos is located approximately one-half mile east of the proposed route near MP 25. No large urban centers are located near the route in Santa Barbara County.

Existing land use characteristics along this first section of the route are typically agricultural. The route would traverse predominantly open land primarily used for the grazing of livestock. Cultivated lands are concentrated in the intermountain valleys or along streams.

From MP 25.7 where the pipeline would intersect U.S. Highway 101, the route continues to traverse open and grazing land. A small oil field would be crossed in the northern section of the county. Approximately 15 miles of the proposed route between MP 40 and MP 55 would traverse Los Padres National Forest. This area is rugged and mountainous in character and is primarily used as open and grazing land. The establishment of Los Padres National Forest removed the land from private ownership and therefore residential, commercial, and industrial development has been restricted.

The Santa Barbara County General Plan depicts most of the south coast region from western Goleta to Point Conception and from the ocean bluffs to Los Padres National Forest zoned U for unlimited agriculture. This zone designation permits all agricultural and most extractive land uses and it also applies to mountainous and scenic areas or areas used as a holding zone.

Santa Barbara County contains many areas of scenic interest. The following scenic corridors would be crossed by the proposed pipeline route:

MP 0-6.5 - Proposed scenic road adjacent to Southern Pacific right-of-way would be paralleled by pipeline.

MP 8.0 - California Route 1 (existing scenic corridor).

MP 14.8 - Santa Rosa Road (existing scenic road).

MP 25.7 - Proposed scenic corridor along existing U.S. Highway 101.

MP 33.0
to MP 38.6 - Tepusquet Road (existing scenic road).

MP 43.0
to MP 43.4 - Tepusquet Road (existing scenic road).

At MP 55.5 the proposed route would enter San Luis Obispo County. The initial 6.5 miles of pipeline through this county would continue to traverse a portion of Los Padres National Forest. As in Santa Barbara County, agriculture is still an important land use in San Luis Obispo County as is evident by the continuing increases in agricultural output.

Specific zoning designations vary from county to county. The entire pipeline through San Luis Obispo County would pass through areas which are zoned U. The U designation applies to an unclassified district in which a wide variety of agricultural and nonagricultural uses are permitted. A U zoning district encompasses all of the land in any unincorporated portion of the county which is not specifically classified by the ordinances of some other designation. The entire pipeline route through San Luis Obispo County would traverse dry farm and grain land, marginal rangeland, and multi-use open space land, as specified in the county's open space portion of the General Plan.

No major urban areas exist in San Luis Obispo County, in close proximity to the pipeline route. The growth patterns of the county are such that nearly all of the land uses associated with development and population growth are taking place within or adjacent to established communities. Existing communities are primarily concentrated along the immediate coast line or along U.S. Highway 101 and not in the more isolated interior regions. To the north of MP 70 is the Soda Lake Basin. This area has been the site of a subdivision which currently consists of only a few residences, dirt roads, and open rangeland.

The Caliente and Temblor National Cooperative Land and Wildlife Areas which are managed by the California Fish and Game Department and the U.S. Bureau of Sport Fisheries and Wildlife for wildlife enhancement are located in the eastern portion of San Luis Obispo County. The proposed pipeline route does not cross the Caliente Management Area but does cross several portions of the Temblor Management Area which is northeast of the Carrizo Plain, for a total of approximately 2.9 miles between MP 96 and 100.

The land north and south of the proposed route, near the Temblor Range is primarily used for cattle and occasionally sheep grazing. Along the western side of the Carrizo Plain, dryland wheat and barley crops are cultivated.

There are no rail facilities in the vicinity of the proposed pipeline route and no airports within 10 miles. In addition, no significant roads are presently in existence near the route in San Luis Obispo County.

The proposed pipeline route would enter Kern County at approximately MP 94.9. Kern County is experiencing a great amount of agricultural and industrial development throughout the county. The route through Kern County to MP 133.1 is zoned A, Exclusive Agriculture. This zone designation permits all typical agricultural operations as well as oil and gas production. The route traverses permanent open space, intensive agricultural areas (irrigated orchards or truck farms) and extensive agricultural areas (grazing and dry farms).

From MP 94.9, the pipeline corridor would extend eastward across the fertile San Joaquin Valley. The small town of Maricopa is situated approximately 2 miles north of MP 98.5. At MP 120, the California Aqueduct would be crossed. This aqueduct has recently been able to supply good quality irrigation water to the San Joaquin Valley. This has expanded the development of new orchards and vineyards (intensive agriculture) throughout the area. It is expected that with the continued urbanization of the Bakersfield area and the San Joaquin Valley, that a substantial amount of land presently being utilized for agricultural activities will give way to residential, commercial, industrial, or governmental uses. At the same time, much of the land now left idle will be placed into cultivation to replace that which will be converted to urbanized development.

Near MP 124, the pipeline corridor would intersect Interstate 5, the California portion of which is a major north-south segment of the interstate highway system. One mile beyond this crossing, Route 99 would be intersected. The only airport within 10 miles of the route is the Taft Airport. It is located 7.5 miles north of MP 86.5. This airport consists of one 60 by 3,250-foot paved runway. Approximately 5,000 to 10,000 take-offs and landings occur at the airport each year.

At MP 133.1, the pipeline would connect with the Arvin-Cajon segment of the route. At this junction, the Point Conception-Arvin segment of pipeline would pivot directly northward for the remaining 9.2 miles. Agricultural use of the land is active in the areas north and south of the Tejon Hills which are situated between MP 137 and MP 140. Near MP 136.5, the route would extend through the Comanche Point Oil Field. The town of Arvin is located approximately 3.5 miles northwest of the Arvin metering station, where this segment of pipeline would terminate at MP 142.3.

The second pipeline which Western proposes to construct would connect with the Point Conception to Arvin pipeline system at a point 9.2 miles south of the Arvin Pressure Limiting Station. This segment would extend for 108.9 miles through portions of Kern, Los Angeles, and San Bernardino Counties to the Cajon metering station.

The land which would be crossed in Kern County is much more diversified and developed than that which would be encountered in the remote areas of Los Angeles and San Bernardino Counties. Land use for the first 10 miles is primarily open space used for grazing and low intensity recreation purposes. Petroleum extraction activities occur in the Tejon Hills Oil Field located between MP 1 and MP 2.5. From MP 10.5 the proposed route descends from the foothills into the Cummings Valley. The primary land uses are the cultivation of grain crops, open space and recreation-oriented subdivided land at Stallion Springs. This community is situated on the Western edge of the valley north of the proposed route between MP 10 and 11.5.

A golf course, clubhouse, facilities, and an extensive system of paved roads are in existence in this second home and retirement development. However, very few residential structures have been constructed as of 1975. The California Correctional Institute would be bypassed near MP 15.

From the eastern Cummings Valley the route extends slightly westward into the Brite Valley. A mixture of field and orchard crops is predominant in this area. The pipeline route then extends into the Tehachapi Valley which contains a wide variety of land uses, including low density residential developments, field and orchard agricultural areas, a second, proposed recreation-oriented land development, and extensive areas of open space used for grazing. The town of Tehachapi is located 1.5 miles north of MP 22. A number of orchards are concentrated in this area just southwest of Tehachapi. Other developed land uses include a small private airport located north of MP 23 and a gravel quarry to the east of the airfield.

The remainder of the route through the Tehachapi Mountains traverses uninhabited and rugged terrain. Recreation, grazing, and transportation are the significant land uses. Three primary roads through the southern Tehachapi's (Willow Springs Road, Oak Creek Road, and Cameron Canyon Road) converge south of MP 28.

Near MP 30 the route emerges into the western region of the Mojave Desert which is basically undeveloped. Even grazing is limited in this area due to the sparse vegetation. The California Portland Cement Company maintains cement quarrying and production facilities at Crail, south of MP 31. Near MP 34.3, the route intersects the Los Angeles Aqueduct.

The only significant concentration of urban residential and commercial development along this route is located in the city of Mojave. The pipeline route would extend past Mojave which is one mile north of MP 39. California Highway 14 and the tracks of the Southern Pacific Railroad's Valley Line and the Atchison, Topeka, and Sante Fe Railroad's Desert Line would be crossed by the pipeline route at MP 39.

Through the remainder of Kern County the existing land use is almost exclusively open space, except for the sewage treatment facilities for the city of Mojave and a few scattered military facilities within Edwards Air Force Base. The pipeline route would transect the northwestern boundary of the Air Force Base at MP 48.6 and would cross this federally-owned property into Los Angeles County at MP 60.9.

In Los Angeles County, the corridor would continue across the undeveloped portions of Edwards AFB for an additional 7.1 miles between MP 60.9 and MP 68. The entire route of 14.2 miles through Los Angeles County is basically undeveloped and uninhabited land. This portion of the Mojave Desert is currently zoned for open space or light agricultural use.

The pipeline route would enter San Bernardino County at MP 75.1. The land use for the first 15 miles within this county repeats the same established pattern of barren open space which characterizes the proposed pipeline corridor through southeastern Kern County and Los Angeles County. There are a few visible signs of unsuccessful developments in this area. They consist of road and subdivision scars. An isolated poultry breeding farm exists south of MP 88.

Near MP 90, the right-of-way pivots south towards the Transverse Ranges. The route would parallel El Mirage Road, a designated scenic corridor. Several rural residential homesteads are clustered along this road. The proposed pipeline would then intersect the Adelanto gas pipeline pressure regulating station at MP 93.1. Near MP 100, the route would intersect the California Aqueduct. Up to MP 100 land use is almost exclusively open space and is intermixed with scattered rural residential areas.

South of MP 100, land use is dominated by open space and transportation corridors. A Southern Pacific Railroad right-of-way at MP 103.1, Interstate Highway 15 at MP 107.6, and the Santa Fe/Union Pacific Cajon Pass mainline at MP 108.5 would also be intersected by the route.

The Conservation Section of the San Bernardino County General Plan governs land use policy for the area between MP 105.7 to MP 108.9. This area is an extensive water conservation zone. The final 2.8 miles of pipeline would traverse a portion of the San Bernardino National Forest where the pipeline would terminate at the Cajon metering station.

Archaeological Resources

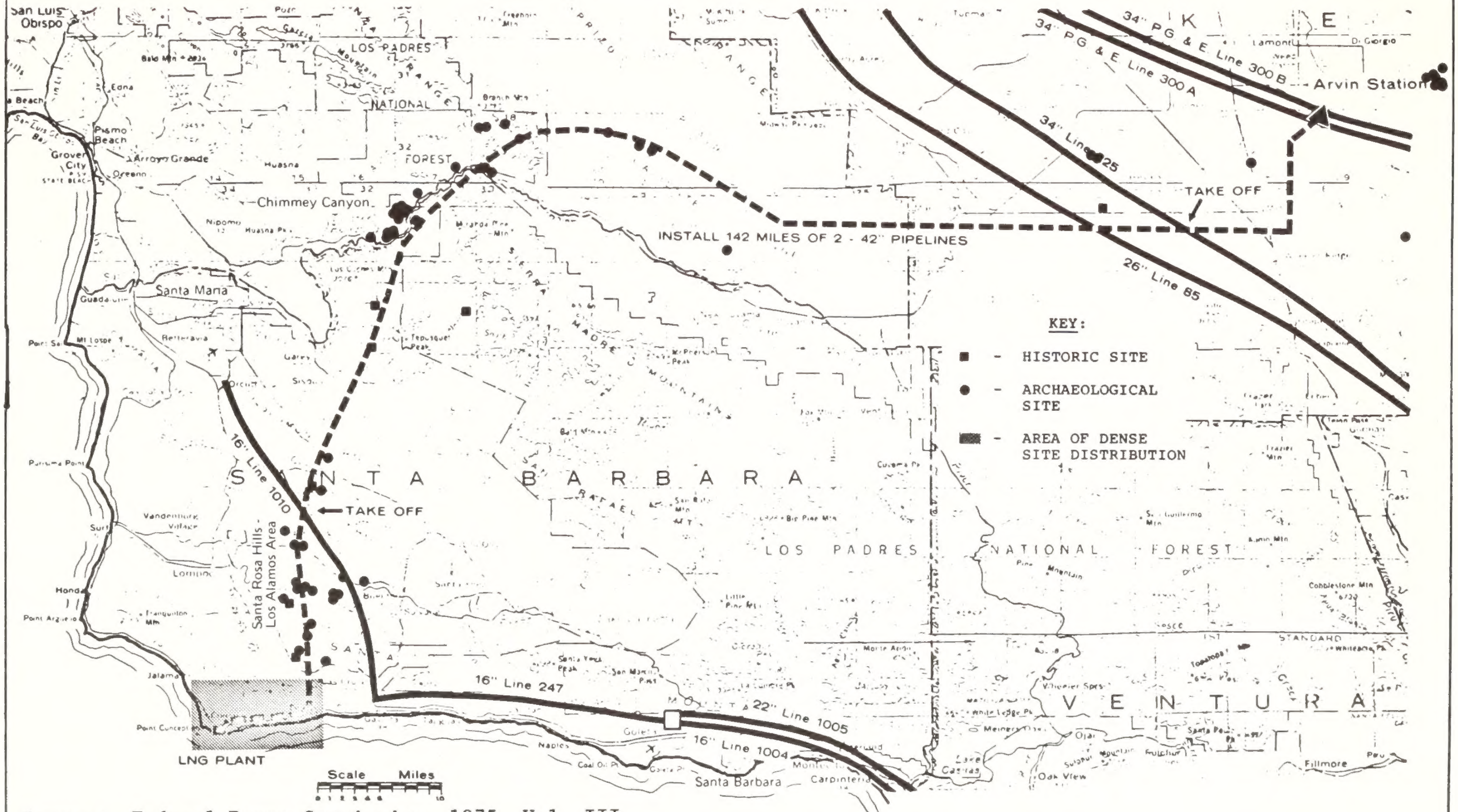
In the summer of 1975, the Federal Power Commission contracted with American Heritage Research of Santa Ana, California, to conduct a literature survey of the known archaeological and historical sites in the areas through which the proposed Western LNG facilities would run. This study, Archeological and Historical Evaluation of California LNG Terminal Sites and Associated Gas Transmission Pipelines was the product of extensive surveys of written reports, monographs and articles located in 28 California repositories and interviews with approximately 100 individuals scholars, avocationalists, state, local and Federal agencies--including the State Historic Preservation Office. All known sites were located as accurately as possible on USGS 7-1/2 minute quadrangle maps. Sites were divided according to impact probability into three categories: sites that would probably be impacted, within 1 mile of the proposed pipeline; sites that faced potential impacts, between 1 and 3 miles from the pipeline; and sites of possible impact, those outside 3 miles but on the quadrangle maps. Since the regasification plant site at Point Conception would include offshore tanker facilities, underwater sites were identified in this area as well.

A total of 131 sites and subsites were located by American Heritage Research. Of these, approximately 40 known sites would be located within the 2-mile wide corridor for the entire length of the pipeline from Point Conception to Cajon Pass. Sites thus far identified include underwater, habitation, burial, pictograph and petroglyph sites. At present no sites within the proposed corridor are listed on the National Register of Historic Places. However, the staff has learned that several archaeological sites in Crowder Canyon at the Cajon Pass terminus have been recently nominated to the National Register.

The data presented in the report by American Heritage Research indicate a clustering of known sites in several locales along the pipeline route. The site of the regasification plant at Point Conception lies in an area of dense site distribution. Two archaeological sites, both of which may be the remains of large Chumash villages, are within the boundaries of the LNG facility. A total of 27 archaeological sites are known for the entire Point Conception area and including underwater sites; 12 would be in areas of high probable impact (see shaded area of Figure 8.2.1.-38).

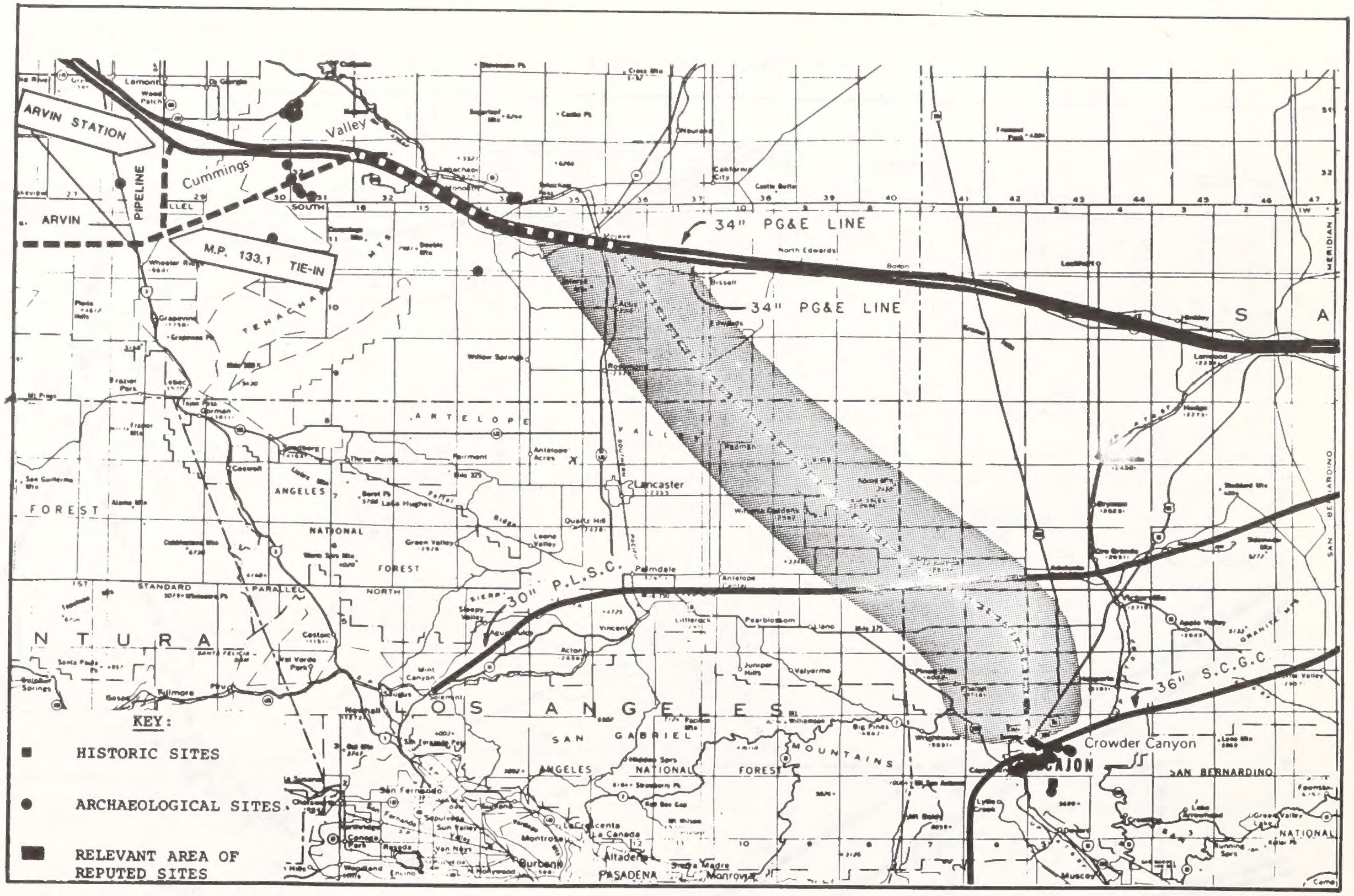
Another clustering of sites appears along the pipeline route just north of the coastline, through the area of Santa Rosa Hills and Los Alamos (see Figure 8.2.1.-38). Here there are a total of 22 sites, 7 of which would be within a mile of the pipeline. Among these sites is a Chumash pictograph site (unnumbered) which suggests that other such finds are located in the area. The Chimney Canyon Quadrangle likewise manifests a high potential for impacts on archaeological sites. Twenty have been thus far identified in this area, most of which are well outside the 2-mile wide pipeline corridor. Nevertheless, this area is reputed to possess many rock art and related sites. The Cajon Quadrangle at the end of the pipeline, contains 23 formally recorded sites, as indicated in Figure 8.2.1.-39. Of these, 14 are located in Crowder Canyon in the immediate vicinity of the proposed regulating and metering station at the Cajon terminus on the north side of Route 138.

In addition to the above-mentioned areas of known site concentrations (which would also possess a high probability for potential sites) a number of other areas have been noted by both American Heritage Research and the applicant as areas of probable site concentration. The portion of the pipeline passing through the Wells Ranch Quadrangle may impact on a considerable number of sites associated with Chumash religious activities as this area was an important aboriginal religious center. The Cummings Valley



Source: Federal Power Commission, 1975, Vol. III

Figure 8.2.1-38 Archeological and historical sites near the Point Conception site and pipeline route



Source: Federal Power Commission, 1975, Vol. III

Figure 8.2.1-39 Archeological and historical sites near the Arvin to Cajon pipeline route

and Tehachapi Mountains are also thought to possess large numbers of potential sites, as indicated generally in Figure 8.2.1.-39. Important early man sites may be encountered throughout the Mojave around the Buckhorn and Rogers dry lakes, as indicated by shading in Figure 8.2.1.-39. Such Pleistocene lake-shores represent areas of high probability for sites of early man.

It must be emphasized that the American Heritage Research report was a literature survey and not a ground survey of the proposed pipeline route. At present there is no way to project the numbers and locations of archaeological resources within the proposed corridor without doing a comprehensive field reconnaissance of the area. The known data itself is frequently of questionable veracity due to the varieties of reporting methods, the age of the data and experience of the reporters. Therefore, any thorough assessment of the existing archaeological resources along this pipeline would require a ground survey by field experienced archaeologists.

Historical Resources

The National Register of Historic Places through the September 2, 1975 Supplement lists one historic site in the immediate vicinity of the pipeline, the Los Alamos Ranch House, 3 miles west of Los Alamos, California. The pipeline would pass approximately 1 to 1-1/2 miles west of Los Alamos and east of the ranch house.

The following state landmarks would be within 3 miles of the pipeline: Old Town, 3 miles west of Tehachapi; Oak Creek Pass, 7 miles southeast of Tehachapi; 20-Mule-Team Borax Terminus, Mojave; Stoddard-Waite Monument, 200 yards north of Cajon Station. Of these sites, Oak Creek Pass is nearest (three-fourths of a mile) the pipeline on existing Oak Creek Road.

Air Quality

The ambient air quality standards for California and the Federal Government are shown in Table 8.2.1.-42. Primary standards are promulgated in order to protect public health, while secondary standards are set in order to protect vegetation, wildlife and materials.

The only air quality monitoring station near Point Conception is located in Santa Barbara, 40 miles to the east. Since the proposed Point Conception regasification plant site area is quite rural and agrarian, while Santa Barbara is a large metropolitan area, it is expected that concentrations of air pollutants would be much lower at Point Conception than at Santa Barbara.

The only other air quality monitoring site that has data reasonably pertinent to the proposed project is in the vicinity of the pipeline route at Bakersfield, which has only a particulate monitor. Because Bakersfield is somewhat more urban than the terminus of the pipeline route, the particulate concentrations at the metering station in Arvin should be lower than the concentrations found in Bakersfield.

Table 8.2.1-43 shows ambient air quality data for Bakersfield and Santa Barbara. The data indicates that both the California and Federal particulate standards are exceeded at Bakersfield and that the California's standards for all pollutants except NO_2 are exceeded in Santa Barbara. Hydrocarbon levels in Santa Barbara are very high due to the large quantity of automobile emissions in the southern California area. Particulate levels are quite high at both monitoring sites due to the dry conditions that would

Table 8.2.1-42 Ambient air quality standards

Pollutant	Averaging Time	California Standards	National Standards	
		Concentration (ug/m^3)	Primary (ug/m^3)	Secondary
Photochemical Oxidants	1 hour	200	160	Same as Primary
Nitrogen Dioxide	Annual Avg.	-	100	66
	1 hour	470	-	
Sulfur Dioxide	Annual Avg.	-	80	-
	24 hour	105	365	-
	3 hour	-	-	1300
	1 hour	1310	-	-
Suspended Particulate matter	Annual Geometric mean	60	75	60
	24 hour	100	260	150
Hydrocarbons	3 hour (6-9 AM)	-	160 (.24 ppm)	Same as Primary

* A dash indicates that no standard has been promulgated for that pollutant and corresponding averaging time.

Source: Federal Power Commission, 1975, Vol. III

Table 8.2.1-43 Ambient levels of pollutants in the vicinity of the proposed site and pipeline, 1974

Site	Sulfur Oxides		Particulates		NO_x	HC
	Annual Arithmetic (ug/m^3)	Maximum 24 hr. Avg. (ug/m^3)	Annual Geometric Mean (ug/m^3)	Max. 24 Hr. Avg. (ug/m^3)	Annual Arith. Mean (ug/m^3)	Annual Arith. Mean (ug/m^3)
Bakersfield 225 Chester Ave.	-	-	130	341	-	-
Santa Barbara 831 State Street	-	-	67	114	72 (a)	3,133 (4,6ppm) (a)

(a) Denotes 1972 data from the California Air Resources Board.

Source: Federal Power Commission, 1975, Vol. III

generate large quantities of airborne dust from extensive agricultural activity in the area.

Noise Quality

A noise survey has not been made at the regasification plant site and specific noise data is not available for the pipeline route.

Because of the remoteness of the proposed terminal site, ambient sound in the vicinity should be very low, and caused by wind, waves, and rains. Infrequent man-made noises occur from occasional automobile traffic along existing access roads.

Based on a review of the topography and land use in the plant site vicinity, it is estimated that daytime equivalent sound levels range from approximately 20 to 40 dB(A) and nighttime equivalent sound levels range from 20 to 30 dB(A). It should be noted that values below 20 dB(A) generally would not be recorded, since instrument noise dominates the record below that level.

Ambient sound measurements in Los Alamos, 1-1/2 mile from the pipeline route, indicate that the daytime sound levels are estimated to range between 50 and 60 dB(A), and nighttime measurements should be approximately 10 dB(A) lower.

At certain points, the pipeline route passes through oil fields, where the noise level is approximately 50 dB(A) at all times.

Utilities

The proposed location of the Point Conception LNG Terminal lies within Southern California Edison Company's (SCE) Santa Barbara electrical service district.

The Santa Barbara district receives most of its power from the SCE generating plants of the Ventura District in western Ventura County. The Ventura district accounts for most of the electrical load of the Ventura-Santa Barbara region, and in 1973 consumed approximately 1.7 billion kilowatt-hours for an average load of 195,790 kilowatts. In the same year, the Santa Barbara district consumed 842.3 million for an average load of 96,150.

In preliminary planning, SCE indicated that the generating capacity of their system is presently sufficient to meet the electrical requirements of the proposed LNG terminal. However, existing SCE substations and transmission systems would not adequately serve the needs of the terminal. Therefore, new electric transmission facilities would have to be constructed to supply the LNG terminal.

Western has not determined what sources of freshwater are available for construction and operation of the LNG terminal. A water moratorium is presently in effect for water districts in the site vicinity. The proposed LNG terminal site is not presently served by any water utility. However, importation of water from the State Water Project (the California Aqueduct) has been suggested so that the local moratorium can be lifted and thereby supplement the freshwater needs of Santa Barbara County. In that event, it is expected that local utilities could possibly have sufficient reserves to supply the freshwater requirements of the LNG terminal regasification plant.

There are presently no sewerage utilities serving the terminal site. Western LNG has proposed to construct their own sanitary sewage treatment system as part of the terminal facility.

Arvin, California To Eastern United States

From Arvin, California the proposed system would transport the regasified LNG to the East and northeast through existing pipeline systems, that for the most part, are already in place. Additional pipeline systems would be required between Waha and Rufugio, Texas and between Dimmitt and Dumas Texas. The additional required facilities follow:

1) 418.5 miles of 42" pipeline and 13.0 miles of 24" pipeline from Waha, Texas to Refugio, Texas.

2) 9.5 miles of 30" pipeline near Waha, Texas

3) 109.7 miles of 20" pipeline from Dimmitt, Texas to Dumas, Texas

4) 1.1 miles of 16" pipeline near Dumas, Texas

5) 12 new compressor stations and 24 modifications to existing pipes and compressor stations at other locations along the existing system.

For purposes of environmental analysis these additions are treated as follows:

1) The corridor from Dimmitt to Dumas, Texas

2) The corridor from Waha to Refugio, Texas

Those developments not associated with these corridors represent mechanical modifications and nominal pipeline alterations. They are not considered significant from an environmental standpoint and are not discussed further in this EIS.

On April 14, 1973 the El Paso Natural Gas Company filed an application with the Federal Power Commission requesting authorization for the construction of a 24-inch O. D. pipeline to transport natural gas westward from existing pipelines located at Refugio, Texas to their Waha plant in Western Texas. This construction would connect existing pipeline systems from the Northeast areas and West Coast areas of the United States. An Environmental Impact Statement was prepared in final form - and released by the Federal Power Commission during April of 1975 (Federal Power Commission, 1975b). Construction of the pipeline is scheduled for 1977. Base information contained in that document has been utilized in the drafting of the sections of this Environmental Impact Statement dealing with the existing environment and impacts between Waha and Refugio, Texas.

Construction of the segment from Dimmit to Dumas Texas would increase the transportation capability of existing pipeline systems that connect the Western - Texas and Alaskan production areas with the northern midwest and Great Lakes areas of the United States. This 20 inch O. D. pipeline would loop an existing system already in place.

Both of the aforementioned corridors will be discussed concurrently throughout the remainder of this EIS.

Climate

The climate of Texas is characterized by extremes in temperature and precipitation rates, and by the variation and extent of catastrophic weather events. The climate patterns of the state are determined primarily by the interaction of moisture-laden Gulf air masses moving in a northwesterly direction and drier, relatively cooler air masses moving southeasterly from the interior of the state.

The proposed pipeline from the Waha plant near Coyanosa, Texas to Refugio, Texas would cross three climatic zones: the semiarid, transition and humid-subtropical. The Waha plant is located in the semiarid climatic zone of the northeastern section of the Chihuahuan Desert in west Texas. The summers are characteristically hot and dry with 10 to 15 inches of annual rainfall occurring primarily during spring and early summer thundershowers. The winters are characterized by frequent cold periods followed by rapid warming. Light winter snows may occur also.

Moving toward the southeast through a transition zone, rainfall becomes more abundant and the semiarid climate gradually gives way to one of a humid, subtropical nature.

The humid-subtropical climatic zone extends from the San Antonio area to the Gulf Coast and is characterized by hot, humid summers and mild winters. Rainfall averages 25 to 30 inches per year with significant quantities being deposited from June to October by tropical storms and hurricanes. In general, hurricanes and tornado frequencies increase with eastward movement. Of 41 hurricanes recorded in Texas between 1886 and 1970 only 9 passed within 50 miles of the proposed Rufugio Station, and 2 passed within 50 miles of the proposed construction sites. Past hurricane records indicate that hurricane force winds would be expected about once every 9 years at the Refugio site and less at the other sites. The occurrence of tornadoes is another type of catastrophic weather condition found in the Coastal Plains area. The calculated probability of tornadoes occurring within 1 mile of the proposed sites equals 1.4 per year at the Refugio site and less along the remainder of the proposed route.

Topography

The two sections of the proposed pipeline requiring new construction would traverse sections of the Great Plains and Gulf Coastal Plains Provinces. The Dimmitt to Dumas section would lie in the Southern Highlands section of the Great Plains, commonly termed the High Plains. This nearly level plain is largely devoid of surface water except for scattered playa lakes. The western section of the Waha to Refugio segment originates in the Pecos Valley section of the Great Plains. The Pecos Valley consists of a long trough lying between the High Plains section to the northeast and the Basin and Range section to the Southwest. The Pecos River flows through a valley 5 to 30 miles in width and an average of 1,000 feet below the adjoining uplands. The valley floor consists of alluvium several hundred feet deep.

Moving eastward the proposed pipeline would leave the Pecos valley and enter the Edwards Plateau section of the Great Plains. The Edwards Plateau is a furrowed or striated plain being slowly eroded by streams. On the high plain, draws usually carry storm waters only. Farther down, the draws become deep valleys and canyons with flat floors are eventually formed. These canyons are frequently several miles wide and covered with deciduous forests.

The proposed pipeline route would leave the Great Plains and pass through the Balcones, Nacogdoches, Oakville, and Hockley Escarpments and continue southeastward across the Gulf Coastal Plain Province before connecting with existing pipelines near Refugio.

The Balcones, with a total displacement of up to 1,700 feet has major topographic expression. It separates the Cretaceous strata of the Edwards Plateau from the Cretaceous, Tertiary, and Quaternary strata of the Gulf Coastal Plain. Several of the remaining fault zones, like the Charlotte and Mirando-Provident City zones, have fractures which reach the surface. However, fractures in most zones do not come closer to the surface than several thousand feet.

Geology

The ancient land mass Llanoria occupied much of the present Coastal Plain section during most of the Paleozoic Era. When the hills and mountains of eastern Texas eroded, their sediment provided the material which subsequently became the rock layers of the West Texas plains. During periods of the Mesozoic Era, Texas was entirely submerged by the sea, and as sediments were precipitated they eventually formed the limestone masses which now constitute the Edwards Plateau. There followed an uplift of the Texas plains which slanted them eastward along the Balcones Escarpment.

The coastline of Texas gradually receded to the southeast in the Cenozoic Era, with the interior slowly uplifting. Volcanic activities occurred in western Texas, resulting in mountain building and dispersal of volcanic ash which was deposited on the Coastal Plain.

In the Gulf Coastal Plain the rock strata have formed a large basin gently sloping to the southeast and marked by a series of fault zones subparallel to the coast. The younger fault zones, deeper and closer to the coast, are Late Tertiary to Recent in geologic age and are associated with sediment overloads and consolidation. The older fault zones, away from the coast, are Jurassic to Late Tertiary in age and are connected to subsidence of the continental margin.

There are seven major fault zones in south Texas. No studies have been carried out to date on the rate of displacemnt or movement of faults in the area of the proposed pipeline. There are no records of any presently active faulting. Some minor faulting can result from subsidence which could be caused by groundwater and oil withdrawal, and heavy irrigation.

Stratigraphy--Sedimentary deposits underlie the surface of the proposed route. The youngest deposits are of the Pleistocene Epoch, and lie close to the Gulf of Mexico, with the strata becoming older away from the coast. All but the Lower Cretaceous strata are exposed in the Gulf Coastal Plain. These deposits consist of loose to moderately consolidated strata of sandstone, shale, marl, clay, sand, gravel, limestone, and occasional lenses of volcanic ash and lignite. The Edwards Plateau section of the proposed route consists of Lower Cretaceous formations of limestone, sandstone, and shale. The Pecos Valley section has mainly Quaternary strata.

Seismicity--According to the Seismic Risk Map of the United States most of the proposed pipeline route is located in a "Minor Damage" seismic zone, except for the area near El Paso, which is in a "Moderate Damage" zone. Seven earthquakes were recorded in Western Texas during the period between

1905 and 1966. One of these earthquakes registered between 7 and 8 on the Merca III intensity scale, the other six were of lesser intensity.

Subsidence--Most subsidence in Texas is a consequence of the extraction of groundwater, sulfur, oil, gas, and other belowground deposits. Some areas of the Gulf Coastal Plain have experienced as much as 5 feet of subsidence in a single year. The effect of such subsidence is often seen in renewed movement of existing subsurface faults, which often results in surface movements of existing surface faults, and/or the creation of new surface faults.

Surface subsidence occurs particularily over shallow oil and gas fields in weak, unconsolidated strata, where water or gas are not reinjected to maintain reservoir pressures following withdrawal. Such subsidence occurred in an oil field near Houston resulting in flooding from adjoining Galveston Bay. Groundwater withdrawal in the Houston area has caused surface subsidence and saltwater intrusion into freshwater strata. Heavy irrigation has caused approximately 1 foot of subsidence to occur in Jackson County.

Economic Geology--The geological resources of economic importance in the areas around the two sections of the proposed pipeline consist of building materials such as limestone and clay, fossil fuels, and other minerals. Sandstone, clay, limestone, and gravel are mined in proximity to the proposed routes in various sections of the Gulf Coastal Plains, Edwards Plateau, and the Pecos Valley. The limestone deposits are quite large but most are located too far from marketing centers for economical mining. Oyster shell is dredged from the coastal areas of Refugio County and often used as landfill. The Edwards Plateau contains deposits of rock asphalt, gypsum and basalt, as well as enormous amounts of flagstone.

Lignite and bituminous coal deposits are found to the east and southwest of San Antonio, but there are no mining operations close to the proposed rights-of-way. Numerous oil and gas fields and storage areas are located within and/or adjacent to the two sections of the proposed pipeline. Celestite deposits occur in areas of the Edwards Plateau near the proposed construction, but none are presently being mined. The Gulf Coastal Plain has significant uranium deposits with lesser amounts in the Edwards Plateau and Pecos Valley regions. Uranium prospects and mines are found in local areas of Atascosa and Live Oak Counties. Small deposits of copper, silver, lead, zinc, and tin are occasionally found in the Pecos Valley section, with mining operations occurring sporadically. Barite occurs in all physiographic sections traversed by the proposed pipelines, but is mined only in the Pecos Valley area. Halite and sulfur are extracted from salt domes in the Gulf Coastal Plain region. However, none of these domes are located near the expected construction areas. In addition, the West Texas region contains large reserves of native sulfur.

Soils

A listing, by county, of the principle soil types traversed by the proposed pipeline route appears in Table 8.2.1-44. These types form six general categories of soil as shown in Figure 8.2.1-40. The high plains area that would be traversed by the northern section of the pipeline is characterized by topsoils that are typically deep and chestnut brown in color. These topsoils are composed of sand, clay loam and calcareaus materials. Much of the area contains alluvial materials that have been transported by wind and deposited on the area. The subsoil is often composed of clay and limestone.

Table 8.2.1-44 Principal soil types traversed by the proposed Refugio to Waha pipeline

COUNTY	SOIL TYPES	SOIL DEPTH	SLOPE	UNDERLYING MATERIAL
Refugio	Sandy loams to loamy sands	Shallow to moderately deep (8-30 inches)	Nearly level to gently sloping (0 - 3%)	Sandy clay loams, sandy clays, caliche
Goliad	Sandy loams to loamy sands	Shallow to moderately deep (8-30 inches)	Nearly level to gently sloping (0 - 3%)	Sandy clay loams, sandy clays, caliche
Bee	Sandy loams to loamy sands	Shallow to moderately deep (8-30 inches)	Nearly level to gently sloping (0 - 3%)	Sandy clay loams, sandy clays, caliche
	Fine sandy loams to clay loams	Shallow (2-12 inches)	Nearly level to gently sloping (0 - 5%)	Sandy clays, hardened caliche
	Calcareous sandy loams to clay loams	Shallow (8-14 inches)	Nearly level to gently sloping (0 - 5%)	Sandy clay loams, calcareous sandy clays, calcareous sandstones
	Calcareous sandy loams to calcareous clays	Shallow (8-20 inches)	Nearly level to gently sloping (0 - 4%)	Calcareous clays, calcareous sandy clays, calcareous sandstones
Live Oak	Calcareous loams to calcareous clays	Shallow to moderately deep (15-40 inches)	Gently sloping to rolling (3 - 10%)	Calcareous clays, caliche, calcareous tuff

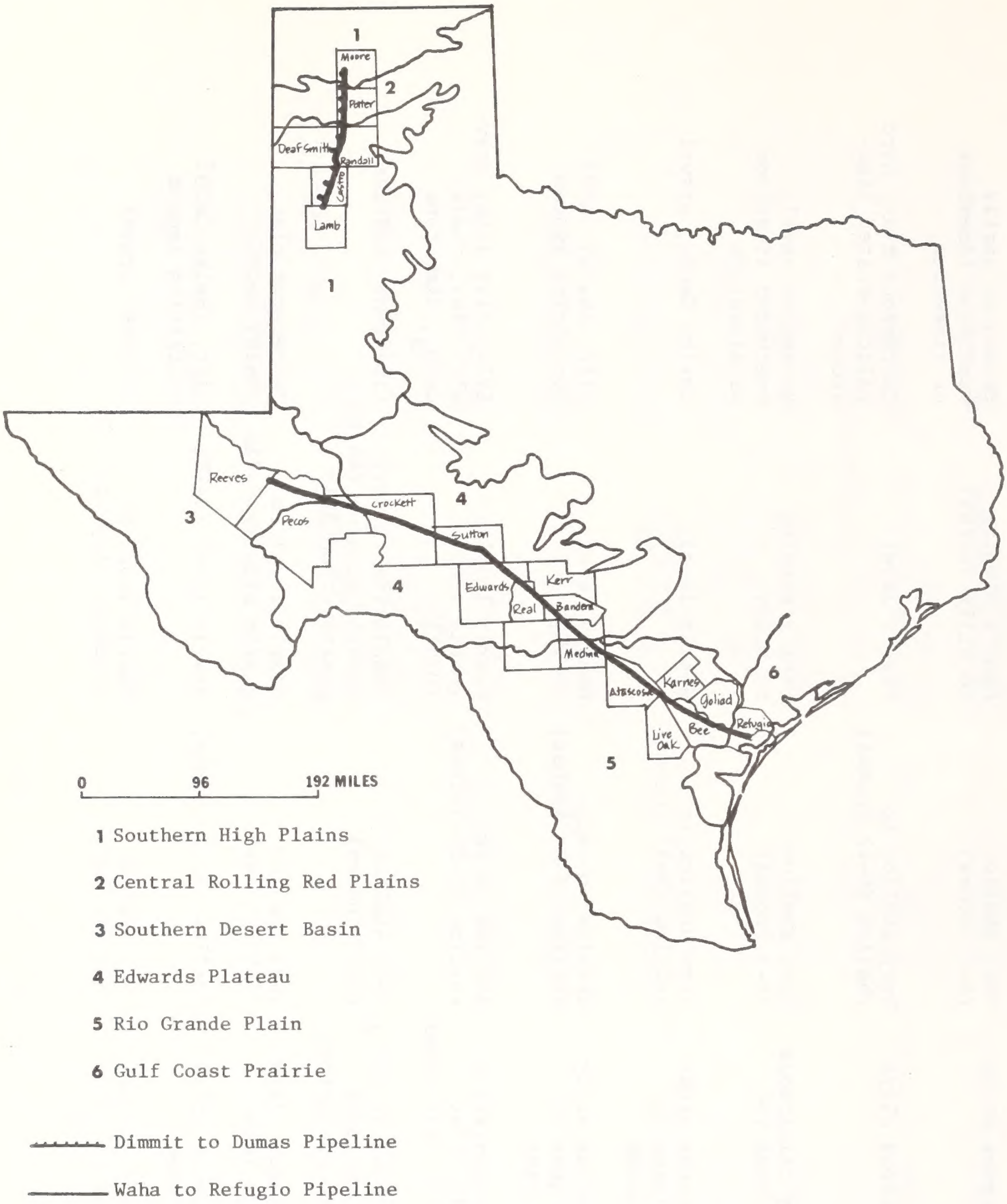
Table 8.2.1-44 Continued

COUNTY	SOIL TYPES	SOIL DEPTH	SLOPE	UNDERLYING MATERIAL
Atascosa	Fine sandy loams to clays	Deep	Nearly level to gently undulating	Clays, clay shales, sandy shales, sands, sandstones
	Fine sands to fine sandy loams	Deep	Nearly level to gently rolling	Silty clay shales, sandstones, sands
Medina	Fine sandy loams to clay loams	Deep	Nearly level to gently undulating	Clays, sands, sandy loams
	Clays to loams	Shallow to deep	Nearly level to gently rolling	Clay loams, clays, caliche
	Clays to loams	Very shallow to moderately shallow	Nearly level to steep	Limestone
Bandera	Silty clays to clay loams	Shallow to deep (20-70 inches)	Nearly level to strongly sloping (0-8%)	Clay loams, silty clay
	Stony clays to calcareous loams	Shallow (6-20 inches)	Gently sloping to hilly (1-15%)	Marls, limestone
	Stony clays to loams	Shallow (6-28 inches)	Gently sloping to sloping (1-8%)	Clays, limestone
Kerr	Stony clays	Shallow	Undulating to hilly	Limestone
Real, Edwards	Stony clays	Very shallow	Undulating to hilly	Limestone
	Stony clays to clays	Shallow to very shallow	Gently undulating to rolling	Limestone, caliche
Sutton	Stony clays to clays	Shallow to very shallow	Gently undulating to rolling	Limestone, caliche
	Stony clays	Very shallow	Undulating to hilly	Limestone

Table 8.2.1-44 Continued

COUNTY	SOIL TYPES	SOIL DEPTH	SLOPE	UNDERLYING MATERIAL
Crockett	Calcareous stony clays	Very shallow (4-8 inches)	Gently sloping to hilly (2-20%)	Broken or partly weathered limestone or limestone
	Calcareous clays	Very shallow to shallow (8-12 inches)	Nearly level	Calcareous clay, hard caliche-coated limestone
	Highly calcareous clay loams to clays	Very shallow (4-8 inches)	Gently sloping to hilly	Broken or partly weathered limestone or limestone
	Calcareous sandy clay loams to clay loams	Very shallow to shallow (6-15 inches)	Nearly level	Chalky $CaCO_3$, gravel
Pecos	Calcareous silty clay loams to silt loams	Shallow to very shallow (8-15 inches)	Nearly level (0-1%)	Silt, chalky $CaCO^3$ containing gypsum
	Calcareous silty gravelly clay loams to silt loams	Shallow to very shallow (6-15 inches)	Nearly level to gently sloping (0-5%)	Silty clay loam, gravelly clay, chalky $CaCO_3$, limestone
	Calcareous gravelly or stony loams, limestone outcrops	Very shallow (3-12 inches)	Undulating to very steeply sloping (8% to greater than 30%)	Limestone, caliche
	Calcareous clays to silt loams	Very shallow (6-12 inches)	Nearly level to gently sloping(0-2%)	Calcareous clay, chalky $CaCO_3$
Reeves	Calcareous silty clay loams	Shallow (8-15 inches)	Nearly level (0-1%)	Silt, chalky $CaCO^3$ containing gypsum
	Calcareous gravelly sandy loams to silt loams	Very shallow (4-12 inches)	Nearly level to strongly sloping(0-8%)	Caliche, gravel

Source: Federal Power Commission, 1975. Refugio - Waha



Source: USDA Soils Associations Map of Texas

Figure 8.2.1-40 Generalized soils map of regions traversed by proposed pipeline routes Waha to Refugio and Dimmitt to Dumas

The Pecos valley section of the proposed route consists of Reddish Brown soils and Red Desert soils. Reddish Brown soils are shallow brown or brownish-red clays and sandy clays underlain by hard caliche. Red Desert soils consist of alluvial outwash from the mountains to the west, varying from silty sands to stony sands. The parent material is made up of stones, gravel and grit. Shallow soils are encountered in the Edwards Plateau region. These soils are light-colored calcareaus stoney clays, and clayey silts, overlaying weathered limestone and caliche. They are typically shallow often with little soil developement and exposed parent materials or bedrock.

Rendzina soils and Reddish chestnut soils occur in the Gulf Coastal plains section of the route. Rendzina soils consist primarily of brown to black clays overlaying soft calcareaus materials and are moderately deep. Reddish chestnut soils are generally deep sandy loams with parent materials consisting of sand and clay.

Vegetation

The proposed pipeline and facilities would cross five major vegetational regions, as indicated in Figure 8.2.1.-41.

The Dimmitt to Dumas section of the proposed route would originate in the Southern High Plains region, cross the Canadian River basin of the Central Rolling Red Plains Region, then reenter and terminate in the Southern High Plains Region. Short and mid grasses are characteristic of the high plains. Except for spots of shinnery oak on some sandy areas, some juniper on breaks, and occasional spots of mesquite and yucca, the region is generally free of brush. The short grasses, buffalograss and the gramas, are most common. The mid grasses, little bluestem, western wheatgrass, side oats grama and galleta are common also. The Rolling Plains Region may be characterized as subhumid. Tall grass and mesquite brush vegetation are common but wheatgrass, gramas and buffalograss are found also. Vine mesquite and shinnery oak are characteristic vegetation in some places. Mollisoils are the predominate soils in the area for this section of the proposed pipeline.

The southern section would originate at Waha and terminate at Refugio Texas. Four vegetative regions are located along the proposed route. To the west the pipeline would begin within the Southern Desert Basin region (Figure 8.2.1.-41). This region lies in the northeastern section of the Chihuahuan Desert and is characterized by hot, dry weather and low precipitation. The region is composed of a combination of rolling grasslands of the volcanic soils, and creosote bush plains, cactus savannahs and agave thickets of the limestone soils.

There is a close relationship between the soils and the vegetation of this region. The mesquite attains only a low growth except in moist low plains, where it grows to a height of 6 to 10 feet. Salt cedar grows high also. Cats-claw, screw bean, greasewood and all other brushy vegetation are rather low and spreading. The principal grasses for grazing are burrowgrass, alkali sacaton, tobosagrass and grama grass. The burrow grass is found on upland country, tobosagrass is found only in the Davis Mountains. Saltgrass grows throughout the Pecos River bottomlands and on practically all areas of shallow alkali soils.

Areas of silty clay loam having chalky material within about 2 feet of the surface are usually covered with salt grass, narrow-leafed sage, allthorn and mesquite. The deep phase of the same type soil supports little

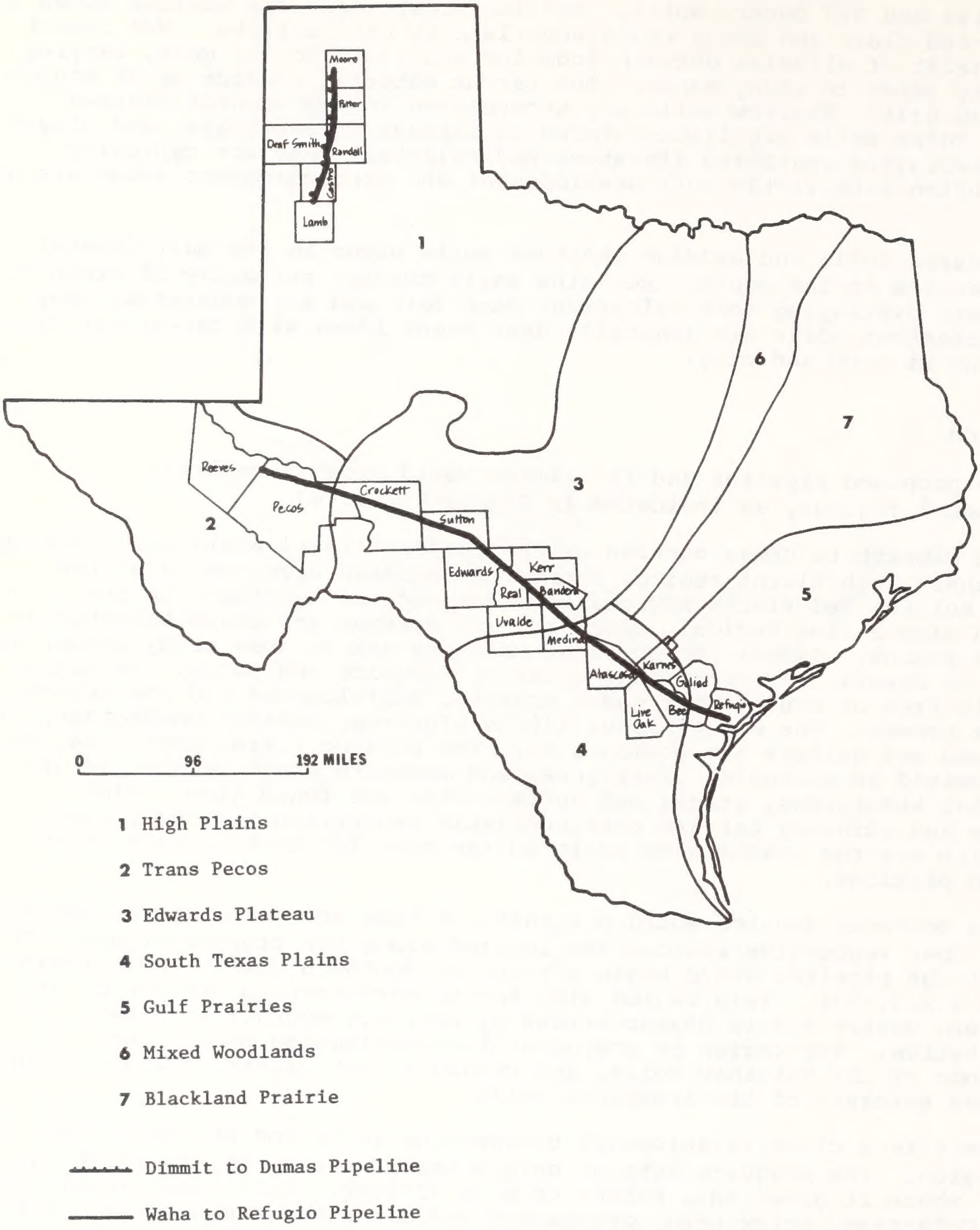


Figure 8.2.1-41 Vegetation regions traversed by proposed pipelines

vegetation other than greasewood or creosote bush, varnish bush, and burro grass.

The areas of limestone soil support the yellow-flowered agave commonly known as lechuguilla. On the drier rocky mesas and hillsides the narrow leaved sotol and barrel cactus are often encountered along with the honey mesquite which even extends into the dunes areas.

The second vegetational region encountered is that of the Edwards Plateau. The region is a part of the southernmost extension of the Great Plains grassland. The presence of a rather heterogeneous group of plants indicates the affinities of the vegetation to elements of both the tall and short-grass prairies.

The range is basically a semi-open grassland probably best described as a mixed grass-forb-woodland association. Bluestems, grama grasses, panic grasses, three awns, dropseeds, windmill grasses, buffalo grass, and curley mesquite are the most important grasses. The low-growing woodland has been designated as a post oak-hickory-mesquite association. Live oak replaces post oak on many sites, but both species may be found together. Shumard oak and lacey oak are abundant and of great importance as forage to deer and domestic livestock in the limestone soils of the area.

Black hickory is a frequent associate of post oak. Mesquite is the most abundant tree of the region and is found primarily on the basin floors where it often forms a closed canopy in flats and abandoned fields. The Texas persimmon is common on rocky ridges and slopes, but may be found also on well-drained flats.

Shrubs are numerous with white brush being the most abundant species. It often invades pastures where woody vegetation has been removed, and often develops dense, almost impenetrable thickets. Catclaw and other acacias, agarito, lotebush, bluewood, lime picklyash and ashe juniper are abundant species also. Prickly pear and tasajillo are abundant in some areas.

The third major vegetative region traversed by the proposed pipeline is the Rio Grande Plains. This region is composed of four major soil groups which dictate the vegetation types to be found.

The areas of deep sands comprise the first group and include three associated vegetational aspects. The first is the live oak aspect. The frequency of these oaks ranges from dense stands with little underbrush in uniformly drained areas to semi-open savannahs in areas of varying drainage and sand depth. The second aspect, the post oak, generally replaces the live oak in areas of decreased soil permeability and decreased sand depth. Blackjack oak and hickory are commonly mixed with the post oak. Dense stands of this hardwood mixture have an understory of brush.

The third major aspect is the mesquite. These trees are usually in a savannah-type setting with large mature mesquites scattered in small thickets or singly over the grassland. Other woods species are not abundant.

The second soil group is that of the deep loams and clays. The major vegetational aspect of this group is the mature mesquite forest. Woody species of understory are variable and prominent with local composition depending on soil variety, rainfall, and temperature.

The third soil group is that of the shallow soils. This group is composed of three scrubby, chaparral-type aspects. The first aspect is dominated by the guajillo bush. This type of vegetation occurs on small mesas fingering out from the Balcones Escarpment. These ridgetops are dominated by dense stands of the guajillo bush which do not usually exceed 7 1/2 feet in height. A wide variety of other low growing woody shrubs interspersed with the guajillo is characteristic, but only represent a small portion of the total vegetation canopy.

The second shallow soil aspect is termed the Rio Grande Slopes. This subtype is confined to the lateral ridge-valley complex. Ridge tops are generally rocky with little soil, while the valleys are usually narrow and actively eroding. The vegetation is dominated by a variety of low shrubs, cacti, and yuccas of variable density with small grassy areas in open sites.

The third subtype is the Freer Mixed Brush. This subtype is found largely along a line of broken uplands associated with a geologic fault extending from Starr County through Bee County. Vegetation consists of a wide variety of woody shrubs with black bush, spiny hackberry, cenizo and various species of Condalia prominent. Guajillo is present but seldom dominant.

The fourth and final soil group is composed of the saline soils. These areas are hardlands range sites which have appreciable concentrations of sodium salts in the upper profile. This tends to limit the growth form of woody species to stunted types and to eliminate other species altogether. Running mesquite, Texas varilla or saladillo, dwarf screwbean, prickly pear, and bare ground with deposits of sodium salts characterize this vegetational aspect. Alkali sacaton and giant sacaton may also be found. In areas of high rainfall mesquite forests may develop similiar in nature to these of the deep loams and clays.

The last vegetative region crossed by the proposed pipeline route is the Gulf Coast Prairie Region. This region extends inland to a distance of 50 to 75 miles from the coast. The topography of this area is almost flat. In some areas, the terrain is so flat that natural drainage is poor. Nevertheless, very little marshy land occurs except in the eastern portion near the Gulf. The elevation on the coast is only a few feet above sea level. Moving inland there is a gradual increase in elevation until, at around 250 feet, rolling hill-country is encountered. The surface has a very slight slope to the southeast.

The major soil types of the area are fine sandy loams ranging in depth from 8 to 20 inches. Associated with this area are large expanses of grasses. The dominant species at the proposed Refugio Compressor site include broomweed, windmill grass, sandbur, and foxtail. To the northwest along the proposed route, unimproved rangeland occurs with scattered mesquite, acacia, and prickly pear, with broomweed as the dominant species.

Wildlife

The proposed pipeline right-of-ways would extend for over 500 miles and cross numerous wildlife habitats. Consistent with other sections of this report, the habitats are grouped together and described in accordance with the five previously described vegetational regions (figure 8.2.1.-41). Species range is discussed only relative to the pipeline environs and vegetational regions and in no way is meant to represent the entire distribution of any species.

The High Plains (Region I) being devoted principally to cattle grazing and wheat ranching sustains a relatively limited resident fauna, reflecting the limited diversity of habitats.

At least 180 species of birds have been recorded from the region, most of them occurring as migrants or winter residents. Among the more spectacular species is the lesser sandhill crane which uses the area's wheatlands during winter. Associated with the prairie environment is a variety of hawks (e.g., red-tailed, swainsons's, American kestrel, etc.). Scaled quail utilize native vegetation while the ring-necked pheasant relies largely upon cover associated with irrigated crops.

At least 55 species of mammals occur in this region. Larger animals include both the white-tailed and mule deer, pronghorned antelope, coyotes and bobcat. Included in the smaller mammal populations are such species as the swift fox, raccoon, porcupine, striped skunk, badger and a variety of small rodents. Some of these species, such as the white-tailed deer, have adapted well to man's modification of the environment and their abundance has approached or exceeded historical population numbers.

A variety of amphibian and reptiles occur in this region also. Representative species include diamondback and prairie rattlesnakes, blue racer, bullsnake, horned lizzard and box turtle.

Region II is the Trans-Pecos region. This arid region provides residence for an estimated 14 species of amphibians, 51 species of reptiles, 80 species of birds, and 61 species of mammals.

Out of the estimated 65 species of amphibians and reptiles there are 3 restricted amphibians (canyon treefrog, great plains toad and plains spadefoot toad) and 6 restricted reptiles (sideblotched lizard, checkered whiptail, western whiptail, Trans-Pecos rat snake, western hook-nosed snake, and the Arizona black rattlesnake). There are no known rare or endangered species of amphibians or reptiles occurring in the Trans-Pecos region.

The avifauna of the Trans-Pecos region is composed of members of both eastern and western United States genera. There are an estimated 141 species of birds that may appear during the year in the region; out of these there are approximately 80 resident species which are typically found in the desert scrub-type habitat of this region.

There are four known rare or endangered birds in this region the bald eagle, peregrine falcon, burrowing owl, and black-capped vireo.

The resident game birds along the proposed route consist of several scaled quail coveys and a sparse population of mourning doves.

The mammalian fauna of this region is comprised of an estimated 61 species of which 13 are restricted. They are the desert fox, Texas antelope, ground squirrel, botta pocket gopher, chestnut-faced pocket gopher, Nelson pocket mouse, silky pocket mouse, desert pocket mouse, bannertail kangaroo rat, Merriam kangaroo rat, western harvest mouse, southern grasshopper mouse, muskrat and mule deer. This area also contains four known rare or endangered speciesthe blackfooted ferret, desert fox (Vulpes macrotis), cougar, and black-tailed prairie dog.

Among the more numerous species of this region are the rock and cave-dwelling bats, such as the pallid cave bat, although rodents do tend to dominate the area with 33 species.

Both white-tailed and mule deer occur in the Trans-Pecos region; however, mule deer occur only in low population densities. Small populations of pronghorn antelope and javelina may also be present.

Region III is the Edwards Plateau. Within this region occur an estimated resident population of 16 species of amphibians, 67 species of reptiles, 86 species of birds, and 63 species of mammals. Three species of amphibians (Texas salamander, slimy salamander, and barking frog) and six species of reptiles (stinkpot turtle, Texas map turtle, canyon lizard, Texas alligator lizard, lined snake, and smooth earth snake) are restricted to the Edwards Plateau region. There are no rare or endangered reptiles and only one amphibian, the Texas blind salamander, in this region.

The avifauna of this region is most commonly associated with the predominant live oak forest. Moderately-sized migratory populations frequent the area during the spring and fall, and several hawk species winter in the area. The Edwards Plateau region also includes the only bird species that nests exclusively in Texas, the golden-cheeked warbler. This small bird nests primarily in cedars and oaks common to the area and is considered a rare species. Other rare or endangered birds of this region include the peregrine falcon, burrowing owl, and the black-capped vireo.

Principal game bird species include the wild turkey, bobwhite quail, scaled quail, and mourning dove. Turkey populations range from moderate in western Medina and Bandera Counties to heavy in Real County, especially along the Frio and Nueces rivers. Turkey roosts have been observed along the proposed pipeline route in southern Sutton County. One roost occurs close to proposed compressor station site 3. Quail populations are light to moderate in eastern portions of the region and scarce to absent in western portions. All counties in the region support moderate to heavy mourning dove populations.

Of the estimated 63 species of mammals, which occur in the region, only 1, the woodrat, is restricted. This region also contains four rare or endangered species, the black-footed ferret, ocelot, cougar, and black-tailed prairie dog.

The Edwards Plateau contains high populations of white-tailed deer and javelina and is the center of hunting activity in Texas. More than 135,000 deer are killed annually in the Edwards Plateau, representing nearly half the total kill for the entire state.

In addition to native mammals, the vegetation and climate of the Edwards Plateau is also conducive to the rearing of several exotic game species. The majority of these exotics have been introduced on private rances and are used to attract hunters.

Region IV is the South Texas Plains. Within this region lie the resident ranges of 19 species of amphibians, 44 reptilian species, 69 species of birds, and 56 species of mammals.

Of the 74 species of amphibians and reptiles found in this region, only 1 amphibian species (Valdina Farms salamander) and 2 reptilian species (Texas garter snake and the prairie skink) do not occur elsewhere along the corridor. The only rare or endangered amphibian is the Valdina Farms salamander and the only endangered reptile is the American alligator.

There are about 181 species of birds that may occur in this region during the year. Most of the 69 residents utilize grasslands or nest in mesquite and live oak. The majority of migrant populations are found in the eastern portion of the region. Recreationally important species include the wild turkey, bobwhite quail, scaled quail and mourning dove. The peregrine falcon and burrowing owl are the only rare or endangered birds of this region.

There are an estimated 56 species of mammals which occur in this region. The majority are rodents with only the pine vole restricted to this region. Data from Medina, Atascosa and Live Oak Counties indicate moderate to heavy populations of white-tailed deer, and moderate populations of javelina. Near the western boundary of the region, cougar, ocelot, and bobcat habitats improve, although the cougar and ocelot are rarely seen.

Several exotic mammals have been successfully introduced to the South Texas Plains. These include axis deer (Axis axis), blackbuck (Antilope cervicapra), fallow deer (Dama dama), and mouflon sheep (Ovis sp.), all of which occur in significant numbers.

Within the Gulf Prairies (Region V) reside an estimated 19 species of amphibians, 56 species of reptiles, 56 species of birds, and 49 species of mammals.

Out of the 75 species of amphibians and reptiles occurring in this region, 4 amphibian species (lesser siren, eastern tiger salamander, Hurter's spadefoot toad, and western chorus frog), and 8 reptile species (green anole, keeled earless lizard, slender glass lizard, prairie kingsnake, Gulf saltmarsh snake, broad-banded water snake, timber rattlesnake, and scarlet snake) are restricted to the Gulf Prairies region. The remaining 14 amphibian and 48 reptile species are also found in one or more of the other regions crossed by the pipeline right-of-way. There are no known rare or endangered amphibian species in this region and only one endangered reptilian species, the American alligator (Alligator mississippiensis).

Proximity to the coast and availabiltiy of suitable habitat accounts for the presence of a large number (103) species) of migratory birds during spring and fall, as well as large wintering populations. A large portion of the avifauna is composed of various waterfowl. The abundance of grassland and cultivated areas in this region provide excellent feeding grounds for both the migratcry and resident species. Of the estimated 56 resident species of the region, those of recreational importance include the wild turkey, bobwhite quail and mourning dove. Several small to moderate populations of wild turkeys are present in southern Bee and in San Patricio Counties, and bobwhite quail occur throughout the region. Mourning doves are present year round with heavy local populations in areas of abundant food supply. There are five known rare or endangered bird species in the Gulf Prairie region: the southern bald eagle, peregrine falcon, Attwater's greater prairie chicken, burrowing owl, and whooping crane.

An estimated 48 species of mammals occur in the Gulf Prairies region, four of them restricted to this region. They are the free-tailed bat, mink, northern rice rat, and swamp rabbit. There are also three known rare or endangered species present--the red wolf (Canis niger), ocelot (Felis pardalis), and cougar (Felis concolor).

The most abundant carnivores are the skunk, raccoon, and coyote; less abundant are the weasel, gray fox and badger.

The principal sport mammal in the region is the white-tailed deer which occurs in brushy areas and cultivated areas.

Aquatic Habitats--The two sections of the proposed pipeline would traverse seven major river basins: The San Antonio-Nueces, Nueces, Colorado and Rio Grande in the south and the Brozoa, Red and Canadian in the north. Seven major streams (Blanco Creek, Atascosa River, Hondo Creek, Pecos River, White River, Red River and Canadian River) would be crossed by the proposed pipeline.

Blanco Creek, a part of the San Antonio-Nueces Coastal Basin, is located in the South Texas Plains region and would be crossed by the proposed pipeline in Bee County. The creek originates in Karnes County and flows approximately 40 miles southeast to Rufugio County where it is a tributary of the Mission River. The primary land usages of the Blanco Creek drainage area are cattle ranching and farming. In the area of the proposed crossing, the creek has an average width of 60 feet, an average depth of 2 feet, and an estimated flow rate of less than 1 cubic foot per second. The dissolved oxygen concentration taken between November and December, 1972, was 14 mg/1 and the pH was 5.8. The creek had a Sechi disk reading of 2.5 feet, a weighted average concentration of dissolved solids of less than 250 mg/1, and a bottom composition of mud and organic detritus.

Sixty-seven species of fish occur in the general area of the South Texas Plains. Eleven species have been found in the creek, including six game fishes: black bullhead, largemouth bass, green sunfish, redear sunfish, bluegill, and longear sunfish. No rare or endangered fish species are known to occur in or near Blanco Creek. No commercial fisheries are near the proposed crossing and recreational use of the creek is limited by its intermittent low flow nature.

The Atascosa River, a part of the Nueces River Basin, is located in the South Texas Plains and would be crossed by the proposed pipeline near the town of McCoy in Atascosa County. The river begins at the Blancones fault and flows to the southeast until it joins the Frio River in Live Oak County. The drainage area of the Atascosa River is used for farming and cattle raising. In the area of the proposed pipeline crossing, the river has an average width of 17.5 feet and an average depth of 1 foot. The estimated flow rate is 7.4 cubic feet per second, the concentration of dissolved oxygen was 12 mg/1, and the pH 5.3. The river has a Sechi disk reading of 2.0 feet and a bottom composition of mud and organic detritus. The weighted average concentration of dissolved solids in the river is estimated to be less than 250 mg/1.

Sixty-seven species of fish occur in the general area around the Atascosa River. Twenty-two of these species are found in the river, including 11 game fishes. The more popular species include the channel catfish, largemouth bass, bluegill, and Rio Grande perch. No rare or endangered fish species are known to occur in the Atascosa River or the surrounding area. No commercial fisheries are in the area of the proposed pipeline crossing, and recreational use is limited because the river is intermittent in several sections and has dense bank vegetation.

Hondo Creek, a part of the Nueces River Basin, located in the Edwards Plateau, would be crossed by the proposed pipeline in Medina County. The creek originates in northwest Medina County and flows in a southerly direction until it joins the Frio River in southern Frio County. The creek is intermittent with small isolated pools and dry sections. Most of the land in the Hondo Creek drainage area is used for cattle grazing. In the area of the proposed crossing, the creek has an average width of 73 feet, an average depth of 7.2 inches and an estimated flow rate of 12.7 cubic feet per second. It has a pH of 6.2 and a dissolved oxygen concentration of 11 mg/1. The creek is clearly visible to the bottom and has a weighted average concentration of dissolved solids of about 200 mg/1. The bottom of the creek consists of bedrock limestone.

Eighty-two fish species occur in the region of the Edwards Plateau. Of these species, 19 have been found in Hondo Creek, including 13 game fishes such as longnosed gar, carp, channel catfish, largemouth bass, and green sunfish. No rare or endangered species of fish have been found in Hondo Creek. However, according to the U.S. Department of the Interior, two rare species, the toothless blindcat and the widemouth blindcat, and two endangered species, the Clear Creek gambusia and the fountain darter, are known to inhabit other streams in the Edwards Plateau. No commercial fisheries are located near the proposed Hondo Creek crossing and recreational use of the creek is limited by its intermittent nature.

The Pecos River, a part of the Rio Grande Basin located in the Trans-Pecos region, would be crossed near the border between Crockett and Pecos counties. The river originates in northern New Mexico and proceeds to flow to the south and southeast until it meets the Rio Grande River in Val Verde County, Texas. The river is highly saline for most of its course through Texas because of discharges of natural brine from aquifers at a reservoir near the Texas-New Mexico border. Concentrations of dissolved solids at that point exceed 7500 mg/1 during 50 percent of the days of flow and chloride concentrations usually exceed 1,000 mg/1. The salinity is increased even more in northern Pecos County because of inflow of saline groundwater, drainage from oil fields, and irrigation return flows. The salinity gradually decreases in the lower half of the Pecos River due to runoff and groundwater discharges low in dissolved solids. The drainage area of the river is used for rangeland and irrigated crops. The Pecos River has an average width of 35 feet and an average depth of 1.1 feet at the proposed pipeline crossing. The estimated flow rate is 35 cubic feet per second, the pH is 5.7 and the concentration of dissolved oxygen is 12 mg/1. The river is clearly visible to the bottom which is composed of mud and organic detritus in the pools, and gravel in the riffles.

Sixty species of fish occur in the general area of the Pecos River. Forty-nine of these species have been found in the river, including 23 game fish such as spotted gar, rainbow trout, channel catfish, spotted bass, bluegill, and yellow perch. The proposed crossing would be in a section of the river regarded as unsuitable for freshwater game fish survival. However, four marine fish species (red drum, Atlantic croaker, spotted sea trout, and southern flounder) have been introduced with moderate success. The Pecos gambusia, an endangered fish species, has been found in small tributaries to the Pecos River. In addition, another endangered species, the Commanche Springs pupfish, occurs in the outflow of Phantom Lake Springs which is in the region of the Pecos River.

Four streams would be crossed by the northern section of the proposed line. These include Running Water Draw of the White River, Tierra Blanca Creek and Palo Duro Creek of the Prairie Dog Town Fork of the Red River, and the Canadian River. Running Water Draw of the White River originates in Parner County. White River joins the Salt Fork of the Brazas River in Dent County. Tierra Blanca Creek enters Deaf Smith County from New Mexico. Palo Drive Creek originates in Deaf Smith County. Tierra Blanca creek and Palo Drive creek unite in Randall County to form the Prairie Dog Town Fork of the Red River. The Canadian River enters Oldham County from New Mexico and crosses the Panhandle region before entering Oklahoma from Hemphill County.

Generally these streams in the area traversed by the proposed pipeline may be characterized as having intermittent flows and remain turbid. The surrounding areas are devoted primarily to farming. Stream channels are wide and shallow.

At least 55 species of fish have been collected from these streams in northern Texas. Game fish found in the area include channel catfish, black bullhead, largemouth bass, smallmouth bass, warmouth, bluegill, green sunfish, longear sunfish and redear sunfish. No rare or endangered species are known to occur in the streams where the pipeline crossings are proposed. The flow of these streams fluctuates considerably. Recreational use of these streams is limited due to their intermittent flow characteristics.

Rare and Endangered Species--Within each of the previously discussed vertebrate classes exist several species which have been designated as rare or endangered on the basis of their present population and/or habitat scarcity.

Among the mammals present, the following have been designated as rare or endangered by either Federal, state, or local authorities: black-tailed prairie dog, black-footed ferret, red wolf, Mexican wolf, ocelot and cougar.

The black-tailed prairie dog typically inhabits short-grass prairies usually avoiding areas of heavy brush and tall grass which interfere with visibility. In the Trans-Pecos and High Plains areas their favorite habitats are alluvial fans at mouths of draws, "hard pan" flats where brush is sparse or absent, and edges of shallow valleys. They live in colonies called "towns" that may vary in size from a few individuals to several thousand. Prairie dogs have been observed in the area of the proposed pipeline.

The endangered black-footed ferret, is considered by some to be the rarest mammal in the United States. This weasel was once common over a wide area, but was impacted severely by programs to suppress prairie dogs with which it was closely associated. Little is known of their exact feeding habits or natural history but they apparently feed almost exclusively on the prairie dog and even utilize its burrows for shelter.

The red wolf, another endangered species, once ranged from eastern Texas and southern Indiana through the Southeast, but in recent years their numbers and their range have drastically declined. Today they are restricted to range in eastern Texas and Louisiana. Little is known of their habits and they are difficult to distinguish from the coyote when seen in the wild. They inhabit brushy and forested areas, as well as coastal prairies and have been recently reported in Refugio and San Patricio Counties.

The Mexican wolf, a subspecies of the gray wolf, was apparently exterminated in the United States during the 1940's, but has reappeared in recent years. Reports from the Trans-Pecos area suggest that they may be starting to reinhabit parts of their former range and could possibly be encountered along the pipeline route.

The desert fox, considered as rare by the state of Texas, generally lives in the open desert of the Trans-Pecos region and prefers mesa country along the borders of valleys. They hunt in the open where their dens are located, and appear to rely on their speed and nearness of their den for safety. They are relatively unafraid of man and are easily trapped, thus predator control programs have greatly reduced or even eliminated these animals in some areas.

The ocelot, classified by Texas as a rare species, may be found along the Gulf Coast and in southern Texas. It is a mediun-sized spotted and blotched cat about the size of a bobcat. In southern Texas, the ocelot inhabits dense, almost impenetrable chaparral thickets where the thorny vegetation offers seclusion. In more forested areas they may be found in the roughest and rockiest areas, and in dense vegetation. With the clearing of rangeland for grazing and farming the dependency of the ocelot on dense cover has gradually led to the reduction in its range. Predator control practices have also caused a decline in the number of ocelots.

The cougar, another rare species by state classification, is a large unspotted cat of fairly wide distribution in Texas. Cougars are retiring and shy by nature and generally nocturnal. They are adept at climbing trees and often do so when pursued by dogs. Their favorite habitats are rocky, precipitous canyons, escarpments, rimrocks, or dense brush. They seldom use caves as dens and much prefer overhanging ledges, dry cavities in rock piles, enlarged badger burrows, or dense thickets. The food of the cougar is chiefly meat with some vegetable material. Deer comprise the majority of their diet along with rabbits, foxes, skunks, rodents, and occasionally domestic stock. In general, the cougar's food habits are neutral or beneficial from a game management standpoint. They are commonly killed for fear they will attack domestic livestock. This has placed the cougar in a precarious situation in many areas of Texas.

The class Aves is represented by seven rare or endangered species (southern bald eagle, peregrine falcon, Attwater's greater prairie chicken, burrowing owl, blackcapped vireo, golden-cheeked warbler, and the whooping crane).

The southern bald eagle, an endangered species, is found nesting primarily in estuarine areas of the Gulf Coast although some do wander northward during the summer and after the nesting season. The diet includes fish and small mammals, which sometimes contain high concentrations of chlorinated hydrocarbon-type pesticides. These have led to a decrease in nesting success because of egg shell breakage resulting from the ingestion of these pesticides. Also, increased human activity around nesting sites, illegal shooting, and loss of nest trees have contributed to their decline.

The American peregrine falcon breeds from the non-arctic portions of Alaska and Canada south to Baja California, central Arizona and Mexico. It tends to winter in the same range although the more northerly flocks move southward. In the U.S., this species was exterpated from its range east the Rockies and now exists only as sparsely scattered aeries in the West. The recent decline is attributed primarily to pesticides. A very limited number of aeries are known to exist in western Texas in the general vicinity of the pipeline between Waha and the Edwards Plateau.

The Arctic peregrine falcon which breeds in the treeless tundra of Canada and Alaska, winters along the Gulf Coast of the U.S., Central and South America. The southeastern extremity of the pipeline approaches this important wintering habitat; however, the falcon's seasonal range is generally confused to the coastal environ beyond the pipeline corridor.

The Attwaters prairie chicken is in its endangered state due primarily to the progressive intrusions which have been made into the tall grass prairie. This coastal prairie country has undergone extensive conversion for grazing and production of grain sorghum. Any further reduction of prairie can be expected to further stress this species. Especially important will be the terminal 20 miles of the Waha Refugio corridor as this traverses one of the two counties regarded as the principle range remaining for the Attwaters prairie chicken.

The burrowing owl, reported as rare in Texas, is an inhabitant of the open grassy plains and is often closely associated with prairie dog towns, using the burrows for shelter. These owls are largely diurnal. Their chief food source is small rodents.

The black-capped vireo, another rare species in Texas, is a resident of the scrub-oak, brushy hillsides, primarily in the Edwards Plateau south to Coahulia. These birds are primarily insect eaters who particularly like caterpillars.

The golden-cheeked warbler, a rare species which breeds only in Texas, is found in juniper-oak canyons on the Edwards Plateau west to San Angelo and east to Austin and San Antonio. Their diet consists primarily of insects and other small invertebrates.

The whooping crane is an endangered species which breeds in Canada and winters along the Gulf Coast, particularly on the Arkansas National Wildlife Refuge which is approximately 25 miles east of the Refugio area. These birds generally feed on grains and small aquatic animal life. In 1938 there were only 14 known representatives of this species. Through establishment of protected breeding and wintering grounds, general awareness of their status by hunters, provision of fenced feeding grounds, and artificial hatching of some of their eggs there are now an estimated 59 birds in the wild and 21 in captivity. Matagordo Island, an area commonly used by the cranes, lies offshore from Refugio. However, the normal winter range does not include the area traversed by the pipeline.

Only one amphibian (Valdina Farms salamander) and one reptile (American alligator) are considered as rare or endangered in the areas affected by the proposed project.

The Valdina Farms salamander, a rare species, is a small (2 to 3 1/2-inch), neotenic cave salamander known only from the Valdina Farms Sinkhole, a cave in northwestern Medina County. They are completely aquatic and are difficult to distinguish from the larvae of salamanders that normally transform into a gill-less adult form.

The American alligator, an endangered species, is a characteristic resident of swamps, lakes and marshes along the Gulf Plains. They are carnivorous and feed on various aquatic and semi-aquatic animals. Recent surveys indicate an increase in the number of alligators in response to protection.

Within the class Osteichthyes, there are six rare or endangered species that may be encountered in the regions traversed by the proposed project; toothless blindcat, widemouth blindcat, Comanche Springs pupfish, Clear Creek gambusia, Pecos gambusia and fountain darter.

The toothless blindcat (Trogloglanis pattersoni) is a rare cave-dwelling species of catfish which is eyeless and without skin pigment. It occurs in various artesian wells near the San Antonio area. Withdrawal of large amounts of groundwater and artesian supplies, and dumping of toxic wastes have been the major factors leading to its decline.

The widemouth blindcat (Satan eurystomus), a rare species is found in artesian wells of Edwards Limestone areas. Again, dumping of toxic substances and withdrawal of large amounts of water have resulted in their decline.

The Comanche Springs pupfish (Cyprinodon elegans), considered an endangered species, is found in the outflow of Phantom Lake Springs, near Toyahvale, Texas. This species is endangered due to large fish kills caused by toxins and a lowering of the water table.

The Clear Creek gambusia (Gambusia heterochir), an endangered species, is found in the headwaters of Clear Creek, 10.4 miles west of Menard, Menard

County. Its existence is threatened by competition with Gambusia affinis and the proposed construction of a dam.

The Pecos gambusia (Gambusia nobilis), also an endangered species, once found in springs and spring-fed ditches of the Pecos River drainage, is now extinct at two previous sites and is presently limited to spring-fed ditches around Toyahvale and a spring near Fort Stockton, Texas.

The endangered fountain darter (Etheostoma fonticala) is confined to Comal and San Marcos Springs and their outflows in Hays and Comal Counties approximately 50 miles north of the proposed pipeline alignment.

Socio-Economic Considerations

The population of Texas has grown substantially during the past century, and centers of concentration have shifted from a predominantly rural agricultural economy to a more balanced agricultural, industrial and commercial economy.

Between 1880 and 1960, the population of Texas increased from about 1.5 million to 9.5 million - an increase of more than 600 percent. In 1940, only 45 percent of the state's population lived in urban areas, but by 1960, 75 percent of the state's population lived in urban areas. It is estimated that by the year 2020, 84 percent of the population of Texas will be concentrated in urban areas.

The areas through which the proposed pipeline would pass are essentially rural. None of the regions crossed have a high population density and the population growth through the year 2020 is expected to be a low 0.46 percent per year.

The majority of the employed population within 5 miles of the proposed pipeline work in retail and wholesale trade. Twenty-one percent work in agriculture and only 5 percent work in manufacturing.

Land Use

Land usage in the area to be crossed by the proposed pipeline is predominantly agrarian and relates to the amount of annual precipitation and terrestraial environment. The market value of agricultural sales is about evenly divided between crops and livestock.

Land use plans for the areas that would be crossed by the proposed project are still in the developmental stages so that specific affects cannot yet be determined. However, since most of the project area is crop or pasture land located considerable distances from areas of high population densities the probable effects on recreational or scenic development would be minimal.

The High Plains area is devoted primarily to agriculture. Large areas are irrigated. Cotton, wheat, grain sorghum and vegetables are grown extensively throughout much of the area. In addition much of the area is utilized as rangeland.

The Trans-Pecos region is characterized by diverse plains and valleys intermixed with mountain elevations ranging from 3,000 to 8,000 feet. The major land use is rangeland which supports only 5 to 10 cattle per square mile due to the sparse vegetation. Irrigated crops such as cotton, alfalfa, grain sorghum, cantaloupes and sugar beets are grown. Further development of rangelands, recreation facilities and irrigated agriculture are the main potentials for future land use.

The Edwards Plateau region is predominantly a livestock and ranching area with extensive game hunting and fishing areas dispersed throughout. The majority of hunting is on privately-owned land, which is usually leased or day hunted by private ranch owners. Very few public hunting areas are to be found in this region. Production of small grain, grain sorghum, forage and hay crops is limited. The major land use potentials are as range for cattle, goats, sheep and deer; with hunting and other recreational activities also possible.

The South Texas Plains region is characterized by subtropical dryland vegetation consisting of small trees, shrubs, cacti, weeds and various grasses.

The major use of land is for range, but irrigated and dryland cropping of citrus, vegetables, cotton and forages, and hunting of white-wing doves and deer is also important. Expanded dryland and irrigated farming, livestock production, recreation, and winter resorts all have good land use potentials.

The Gulf Prairies region is heavily devoted to agriculture, especially cotton, grain sorghum, rice, and corn farming with the remaining portions used primarily as pastureland. About one-third of the area is cultivated, with a potential for intensive irrigated and non-irrigated cropping and livestock production. Urban, industrial and recreational developments also have potential for future land use.

Other land uses in the area of the proposed pipeline include 12 major military installations. The closest are at Castroville and Hondo, 3 and 9 miles away, respectively. Six are located in the San Antonio area 17 to 40 miles away.

Game fishing in the various lakes and streams of the high plains Edwards Plateau are widespread, and Lake Corpus Christi of the coastal region also contains various species of game fish. There is extensive fishing on private ranch ponds and along the various creeks and rivers which cross the area of the proposed project. Oil and gas fields underlie a large area of land within the vicinity of the proposed pipeline along with various oil storage tanks. The proposed pipeline would pass directly through a number of these fields.

Land use for transportation in the area traversed by the proposed pipeline includes railroad lines, highways, and airports. The pipeline would cross nine railroad tracks.

There are numerous private airstrips located on many of the ranches in the area but only four major commercial airports are within 50 miles of the proposed pipeline. These are located at San Antonio, Corpus Christi, Victoria and Amarillo.

Numerous highways would be crossed also by the proposed pipeline.

Paleontological, Archaeological and Historical Resources

The Department of the Interior records 65 historic and archaeological features within 50 miles of these corridors. Seven of these are situated within ten miles of the proposed pipeline alignment. These designations include those sites which have been determined to be eligible for inclusion in the National Register of Historic Places since sites that are so classified are entitled to protection pursuant to the procedures of the Advisory Council on Historic Preservation. A listing of sites within 10 miles is presented in the following list.

Crockett County: Crockett County Courthouse; Fort Lancaster

Edwards County: Devil's Sinkhole

Medina County: Castroville Historic District; Landmark Inn Complex;Devine Opera House

Sutton County: Caverns of Sonora

The Texas State Historical Society has indicated that the proposed Waha Refugio pipeline alignment appears to pass through more than 10 known archaeological sites, demonstrating that an archaeological survey on both corridors is necessary.

Thirty-five miles north of Amarillo is the Alibates National Monument which is being considered for development to survey and interpret its archaeological and esthetic resources. It lies adjacent to Lake Meredith and its associated recreation facilities and approximately 25 miles east of the proposed pipeline.

Recreational and Esthetic Resources

Public park and recreation facilities are not extensive along the Dimmitt to Dumas pipeline. The major facility is located on Lake Meredith which is north of Amarillo and about 25 miles east of the corridor. This area, which was opened in 1965, offers a full range of water sports. Other recreation facilities along this pipeline corridor are limited to Palo Duro Canyon State Park south of Amarillo and widely scattered roadside parks, local parks and small lakes.

Along the Waha to Refugio corridor there are at least nine parks and recreational areas located within 50 miles of the proposed pipeline. Each of the parks, listed in Table 8.2.1.-45 has camping and picnicking facilities, except Copano Bay and Port Lavaca.

Four of the areas, Lake Corpus Christi, Copano Bay, Goose Island and Port Lavaca are located in the Gulf coastal area and are used primarily for boating and fishing.

Within the Edwards Plateau "hill country" area are located Kerrville and Garner State Parks which are primarily camping and picnicking areas.

Located in the Trans-Pecos area are Monahans Sandhills Scenic Park and Balmorhea State Park which are 30 and 44 miles, respectively from the Waha plant.

Two National Wildlife Refuges lie near or on the subject corridors. The Aransas N.W.R is located on the Gulf Coast approximately 20 miles beyond the terminus of the pipeline at Refugio. This refuge is the principal wintering area for the endangered whooping cranes. Despite its proximity, the pipeline is not expected to affect this refuge or the wildlife it serves.

Near Amarillo, the pipeline is scheduled to traverse the Buffalo Lake N.W.R. It is to be laid through an existing 60-foot right-of-way. This

Table 8.2.1-45 Recreation and scenic areas within 50 miles of proposed pipeline (1971)

Name	Type	County	Nearest Town	Distance from Pipeline (Miles)
Balmorhea	Recreation	Reeves	Toyahvale	44
Copano Bay	Recreation	Aransas	Rockport	25
Frio Canyon	Scenic	Real	Prade Ranch	14
Garner	Recreation	Uvalde	Concan	37
Goose Island	Recreation	Aransas	Rockport	26
Kerrville	Recreation	Kerr	Kerrville	22
Lake Corpus Christi	Recreation	San Patricio	Mathis	33
Monahans Sandhills	Scenic	Ward	Monahans	30
Port Lavaca	Recreation	Calhoun	Port Lavaca	49

Source: Federal Power Commission, 1975, Refugio - Waha refuge is visited annually by up to 100,000 geese and 750,000 ducks. However, it is expected that damage from this project will be minimal, provided construction is accomplished during summer when wintering waterfowl are not present.

Air Quality

The compressor stations would be the only part of the proposed project emitting air pollutants on a regular basis. The use of natural gas as fuel for the compressor results in only one significant type of air pollutant, nitrogen oxides from gas-fired equipment of 0.2 pounds per million Btu of heat output or approximately 175 ppm by volume. The Environmental Protection Agency Regulations define the acceptable ambient air level for nitrogen dioxide (NO_2) as 100 micrograms per cubic meter (100 $\mu g/m^3$) as an annual arithmetic mean. Data collected during 1971 indicate that annual average NO_2 concentrations levels at five sites along the proposed pipeline range from 10 to 21 $\mu g^2/m^3$. These levels are well below maximum allowable levels.

Impact Analysis

The analysis considers impacts on the project as well as impacts caused by the project. In many cases an impact on the project results in a secondary impact on the environment due to actions taken to offset the primary impact.

The impact analysis is divided into two sections: (1) Summary of Major Impacts, and (2) Detailed Analysis. The discussion follows the same three-part sequence as the preceding descriptive material, that is, Alaska gas pipeline route and the LNG Terminal site, the marine transportation route, and the California regasification site and the pipeline route from California to eastern U.S. (This latter part is discussed in two sections: Point Conception to Cajon, California and Arvin, California to points east).

There are major engineering, location, construction, and navigation uncertainties associated with the proposed Alaska pipeline and liquid natural gas plant, marine transportation system, California regasification plant, and the pipeline across the U.S. Experience in arctic construction is adequate to predict the probable degree of expected change in the existing environment; and where available data are incomplete, the impact analysis so indicates. Similarly, impacts are evaluated on the basis of what may happen if major project elements now planned cannot be achieved.

Summary of Major Impacts

The Pipeline from Prudhoe Bay to Gravina Point and the Gravina Point Terminal

a. Although the propagation of ice fog at compressor stations would be a localized impact, it could be a major safety hazard. The use of aircraft and ground vehicles in ice fog could result in accidents with attendant loss of life and property.

b. Severe winter weather conditions with extended periods of extreme cold, darkness and blowing snow would delay or even halt construction for many days.

The extension of construction activities beyond the scheduled two winters would cause major secondary impacts on both the environment and on people. First, additional damage will occur to the permafrost regime, vegetation, water quality, and other aspects of the environment. Second, delay in construction will delay the delivery of natural gas.

c. Low snowfall, particularly in the North Slope area, would require the use of water to manufacture roads that support winter construction. A major secondary impact would be increased degradation of the permafrost regime because of construction activity across the thawing active layer during the summer season. Soil erosion, slumping, mass wasting, and gullying would all be accentuated by the additional disturbance of the active layer during thaw periods.

d. Use of the limited supply of fresh water during the winter season for camps, the icing of winter roads, the manufacture of snow, and other purposes would cause a major adverse impact on aquatic life. This could be especially disastrous to fish in streams on the North Slope and in the interior of Alaska south of the Brooks Range and north of Fairbanks.

e. The overall impact on topography would be slight, except for the last 40-mile segment of the pipeline from the Lowe River east of Valdez southward to Gravina Point. The pipeline construction through the wilderness country of the Chugach Mountains National Forest and the construction of the LNG plant in the Gravina Point wilderness will cause an adverse impact on the esthetics of topography previously unscathed by man.

f. Approximately 96% (780 miles) of the 810-mile pipeline traverses permafrost. More than 47% (380 miles) of the total mileage is through ice-rich permafrost. Degradation of the permafrost regime is the single, most important environmental factor related to both the construction and operation of the pipeline system. Industry has not demonstrated that a buried, chilled pipeline can be operated safely in the permafrost region, especially in the discontinuous permafrost zone. Impacts will be particularly severe in ice-rich permafrost zones; soil subsidence and gullying could continue for years. Long-term influence on soil, water, vegetation, and wildlife can result from disturbance of the organic protective tundra mat and the initiation of changes in the thermal regime. Unscheduled summer work that results from winter construction cancellations and delays, fire suppression, emergency repair, salvage of pipe, and disturbance of the vegetative mat during snow collection are all forms of activity that accentuate permafrost degradation.

g. Impacts on gravel resources already depleted by the Alaska oil pipeline and haul road will be severe but localized if requirements are held to the 6.7 million cubic yards estimated for the gas pipeline. The modifications or cancellations of winter work schedules that result in more construction activity during the summer thaw period would intensify the project affect on gravel and stream hydrology causing severe adverse impacts on a regional basis. It is estimated that gravel requirements could reach 30 million cubic yards.

h. Approximately 6,202 acres of tundra and taiga vegetation would be permanently destroyed. Such acreage includes 5,247 acres in the 53.5 footwide 810-mile long permanent pipeline right-of-way, 450 acres at Gravina Point for the LNG plant and its auxiliary facilities, and 505 acres for permanent support facilities such as roads, airfields, compressor stations, helicopter pads, maintenance sites, and related facilities. An additional 11,248 acres would be disturbed and degraded by the clearing and scraping of vegetation in site preparation activities on the 150-foot wide pipeline right-of-way, work pads, snow roads, pipe storage areas, river crossings, construction camps and access roads to borrow areas.

i. The possibility of earthquake damage to the pipeline support facilities, the LNG plant, and the LNG tanker docking area cannot be ruled out. The magnitude and time of an earthquake event is not known.

The pipeline system south of the Brooks Range passes through areas having a history or a potential for earthquake shocks ranging from 6.5 to 8.5 on the Richter Scale. A severe earthquake could rupture the pipeline as well as cause ruptures in the ground along the pipeline and at Gravina. Tsunamis or seismic sea waves generated during an earthquake event could destroy the LNG docking facilities and any tankers near or at dockside. The plant is on high ground and is believed safe from any earthquake tsunamis.

j. The impacts of sulfur dioxide emissions on lichens from the compressor stations could be severe, although the .5 ppm peak emission rate from a compressor station is small and well within the standard for Alaska, the unusual nature of the Alaskan environment and the extreme sensitivity of lichen to sulfur dioxide could cause large-scale reduction in lichen communities during the operation of the proposed pipeline. Loss of lichen would have a detrimental impact on caribou populations since lichen is their primary winter food. Impacts on caribou populations would in turn affect Alaskan natives who still depend on the caribou for subsistence.

k. The effects of fire suppression activities on vegetation and permafrost integrity is one of the major and most adverse of all impacts associated with the gas pipeline project.

l. Salvage of pipe from the line could cause long lasting permafrost degradation with its associated gullying and other severe erosive processes.

m. Impacts on wildlife could be severe but would generally be temporary and localized and would primarily be associated with the construction phase. Impacts will be incremental to those of the oil pipeline. The presence of men and equipment will drive away wilderness animals such as the grizzly bear, wolverine, and the wolf. Severe impacts of a longer duration causing adverse affects on animal populations would be the loss of wolf den sites, disturbance of Dall Sheep on their winter and spring calving grounds adjacent to the pipeline in the Brooks Range, destruction of winter foods and displacement from sheltered areas of the small moose herd on the North Slope, and the interruption of nesting of peregrine falcons (an endangered species; adjacent to the route with a possible reduction in populations of this bird.

A major secondary impact would be increased access for legal and illegal hunters and recreationists causing displacement and reduction in animal populations. Potentially severe impacts could result from aircraft harassment of animals during the mating season and during the winter when they could be placed in a negative energy balance situation leading to mortality. The Dall Sheep would be especially vulnerable to aircraft harassment as would the wolf. Destruction of bird nesting habitat would be localized but could have a severe impact on those species requiring very specialized and unique habitats.

n. The impact of the proposed project is adverse and major on the wilderness character of the Prince William Sound Unit of the Chugach Mountains National Forest and the Gravina Point area. This impact encompasses 46 miles of the pipeline system.

o. The three major impacts of the pipeline project on fish life are: water withdrawal during winter freeze-up; spills of fuels, lubricants and methanol; and water turbidity.

p. Under "worst case" conditions, relative to both site of repair work and time of year when repair work would be undertaken, there will be substantial adverse impacts on vegetation, soil, permafrost, water quality, and wildlife resulting from nonwinter emergency repair of the proposed gas pipeline.

q. For people whose appreciation of esthetic qualities are those related to beauty, pure feelings or sensations, or to the congruity of the environmental features, the proposed project would have a significant adverse effect.

r. Water quality can be impacted due to accidental spills of fuel, lubricants, or methanol and overflow from sewage lagoons. Siltation from borrow and disposal sites is also a short-term impact of major importance.

s. Impacts on subsurface water flow will result from decreasing the depth of the active layer over the chilled pipe and increasing the active layer under the work pad and snow/ice road. This may result in ponding at the surface.

t. Blockage of streamflow because of formation of an ice bulb at the bottom of streams can cause large areas of aufeis to form.

u. The once-through cooling water system proposed for the liquefaction plant at Gravina Point would return 658,000 gpm of water to Orca Bay 21° F above ambient seawater temperature. In addition, chlorine used as an anti-fouling biocide and brine will be discharged into Orca Bay. Several species of aquatic vertebrates and invertebrates are found in the area that would receive effluent from the proposed plant. Adult pink, chum, silver and red salmon migrate past the proposed plant site during July and August. Juvenile pink salmon migrate through the area during the period of May through July. Heat and chemicals discharged into the aquatic environment could have a variety of effects upon aquatic organisms. Migratory movements of both juvenile and Atlantic salmon could be altered due to the operation of the liquefaction plant. Fish eggs, larvae and other micro organisms would be passed through the plant - most would succumb. Some macro organisms would be impinged upon screening devices constructed to prevent their entry into the plant.

v. The proposed additions of 300,000 gpm of seawater 12° F below ambient seawater temperature from the revaporization plant into the Pacific Ocean near Point Conception could have an adverse impact upon some of the 721 species of aquatic organisms found in the area. Some warm water species could be forced from the area while cold water species could be adversely affected should the cold water be discontinued without time for their acclimation to the warmer water.

w. The socio-econmic impact of the gas pipeline project will be both adverse and beneficial. It would be the most significant of all project impacts. It would simulate and magnify the boom and bust type of socio-economic impact of the Alaska oil pipeline construction activities. Several thousand workers would fan out to six construction camps along the 810-mile long route. The beneficial impacts include an increased trade for local businesses; an increased tax base for cities; and increased cultural activities. The adverse impacts include: an increase in crime; crowding of schools; inflation; a lower standard and shortage of housing; and an acceleration in the decline of Native culture.

LNG Transport (Marine Route)

The impacts on fish and wildlife caused by the movement of LNG tankers between the LNG plant at Gravina Point in Alaska and the regasification plant at Point Conception in California would be minor. However, an accident involving a single LNG tanker or a collision with another ship would result in the production of a huge super-cooled cloud of gas, a fire, an explosion singly or in combination, or all three resultants in sequence. The possibility of such accidents cannot be discounted.

The greatest chance of an LNG tanker accident would be in Prince William Sound and its entry passage for shipping, the Hinchinbrook Entrance, with the traffic of the huge (1,000-foot long) LNG tankers proceeding to and from the Gravina LNG terminal and the super oil tankers proceeding to and from Valdez. Another factor which would increase the possibility of an accident in the heavily used Prince William Sound shipping lanes lies in the presence of icebergs. Recent studies indicate that the Columbia Glacier could produce annually, for the next 30 to 50 years, a number of large icebergs. Some of these could reach the Prince William Sound navigation routes and pose a serious safety hazard to all boat traffic.

An LNG tanker accident could have severe adverse affects with loss of human life and the destruction of nearby boats, and ships and shore facilities. An accident at or near the LNG plant could wipe out tankers and docking facilities as well as the plant with a catastrophic loss of human life and property. The impact on bald eagles and sea otters could be severe. An accident in Prince William Sound, in addition to the tragic loss of human life, could kill waterfowl and sea otters, similarly, an accident near or at Hinchinbrook Entrance could cause a significant loss of seabirds. An accident anywhere in the Prince William Sound region could result in the destruction cf fishing boats, fishing gear, recreational boats and a loss of human life in addition to the loss of the tanker and its crew.

An accident on the open sea would have a minor effect on fish, wildlife and other aquatic organisms, as well as loss of tanker and crew.

An accident at or near the regasification plant at Point Conception could result in a loss of human life and property similar to the catastrophic losses at the Gravina LNG site.

The most severe impact to fish and wildlife would result from a collision between an LNG tanker and an oil tanker and the resulting oil spill. Depending on the time of year and locale of the event, high mortality among sea birds and waterfowl could result. In certain situations larval forms of shellfish and young finfish could suffer heavy losses from oil spills. Additionally, nets and other fishing gear could be so contaminated as to be useless for future fishing activity.

Point Conception to Cajon and Arvin, California

a. Construction of the regasification plant and use of a corridor from Point Conception to Arvin will require considerable modification to the environment and topography. Two million cubic yards of earth will be moved and two arroyos would be filled at the terminal site. Ridge cuts will be required on 50 percent (71 miles) of the route between Point Conception and Arvin. Since these areas are in areas of moderately high rainfall, erosion could be a problem.

b. Some 22 fault zones would be crossed by the proposed route. Seismic activity should be anticipated.

c. Several generalized soil types would be crossed by the proposed pipeline, including soils with liquefaction and collapsing characteristics. Construction could have a major impact on these soil types. If topsoil is not replaced, soil erosion could become a problem especially along the sections of high rainfall.

d. Operation of the regasification plant at Point Conception will withdraw some 300,000 gpm of water from the ocean for regasification of the LNG. Water returned will be some 12° F colder than the ambient sea water. In addition acrolein will be used to prevent fouling of the evaporization facilities by aquatic organisms. The addition of cooled water and chemicals could have an adverse impact upon the 721 species of marine fauna in the vicinity of the proposed plant. In addition micro organisms would succumb as a result of passing through the plant and macro organisms would be impinged upon the screening structures.

e. Twenty-six rare and endangered plant species are found along the proposed route. Construction could have a significant impact upon one or more of these species.

f. The proposed project would have a significant socio-economic impact upon the areas in the vicinity of the pipeline, especially Santa Barbara county. Housing facilities are insufficient to satisfy the demand of the work force and support personnel required during the projected 39 month period of construction. The total construction payroll is estimated to be some $96 million of which $76 million would be disposable income. Approximately $61 million would be available to Santa Barbara county over the three year construction period. It is estimated that some 300 highly skilled workers and families would be brought into the area for the construction of the LNG terminal. It is anticipated that 600 students would be added to the local school system. The impact will result from a large influx of people to the area within a very short time period and their departure some three years later almost as rapidly.

g. Construction of the proposed Point Conception regasification terminal would have immediate and long-term effects on the present and future land use in Santa Barbara County. The project would involve the installation of a major industrial facility in a primarily rural, agricultural area. The terminal would present a direct conflict with respect to development of the Hollister Ranch which would border the regasification site to the north and extends for many miles to the east. In addition the offshore construction would conflict directly with recreational and commercial use of the offshore area. The construction and operation of the pipeline per se would have a lesser impact on the environment.

Arvin, California to Eastern United States

The impact upon the environment from this section of the proposed pipeline would be minimal. Except for two sections (Dimmit, Texas to Dumas, Texas and Waha, Texas to Refugio, Texas) the route would utilize existing pipeline systems already in place.

Two endangered species of wildlife, the American peregrine falcon and the Attwater's greater prairie chicken, both occur in the region traversed by the Texas portion of the pipeline system. Another endangered species, the Arctic peregrine falcon, is a winter visitor, found primarily around the coast and in open country inland.

The American peregrine falcon is believed to nest in the mountains in west Texas but specific aerie locations are not known. Special care will need to be exercised if they are found in the vicinity of the corridor.

Attwater's greater prairie chicken, which resides in small separated populations in the tall-grass prairies, could be adversely affected if these tall-grass habitats are destroyed. Any further reduction of prairie can be expected to further stress this species. Especially important will be the terminal 20 miles of the Waha-Refugio corridor as this traverses one of the two counties regarded as the principle range remaining for the Attwater's prairie chicken. Placement of the line so as to avoid such areas would reduce this impact.

Detailed Analysis

The Pipeline From Prudhoe Bay to Gravina Point and the Gravina Point Terminal

The placing of a chilled, buried, high-pressure, large diameter natural gas pipeline of this type has no precedent. Therefore no practical experience exists from which to evaluate theoretical design features.

If this route and method of transport are selected for permit, a massive field survey effort will be required. Because of the extreme variability of soil type, temperature, and ice (moisture) content.

Similarly, vegetative, climatic, water, and engineering studies will be needed before pipeline construction starts.

This impact analysis assumes that the most current engineering design principles would be used and assumes compliance with all existing construction and maintenance codes. Arctic conditions create new problems beyond known pipeline technology, however, and it appears that the Code of Federal Regulations does not embrace criteria for pipeline design for the Arctic. It is probable that new types of equipment would need to be developed for construction, operation, and maintenance for the Arctic.

Major engineering, location, and construction uncertainties are associated with this pipeline system. The following analysis of anticipated environmental impacts reflects these uncertanties. However, experience in arctic construction is adequate to predict the probable degree of expected change to the existing environment; and where available data are incomplete, the impact analysis so indicates. Similarly, impacts are evaluated on the basis of what may happen if major project elements cannot be achieved.

Climate--

Pipeline--The primary impact of the gas transmission system on Alaskan climate is, at present, largely unknown but is related to the huge amounts of water vapor from the proposed 30,000 horsepower compressor stations. This is in addition to an unknown amount of similar airborne effluent from the trans-Alaska oil pipeline pump stations. This amount of vapor at high temperatures released into the atmosphere when temperatures are below zero can adversely affect the climate through the propagation of ice fog. Ice fog, a peculiar phenomenon of the arctic climate, is formed from tiny, frozen water droplets. Three factors are necessary for ice fog to form: (a) a temperature lower than -22° F, (b) a moisture source and (c) condensation nuclei present in the air for droplet and ice particle formation. Ice fogs are quite common in the Fairbanks area because of large volumes of vapor emissions from vehicles, heating systems and industries. Particulates from the same sources provide condensation nuclei. Without winds to dissipate it, ice fog often is confined to narrow patches along highways, construction areas and surrounding industrial plants.

Intense radiational cooling during the winter months causes a strong temperature inversion to occur up through 4,000 to 5,000 feet above the terrain. Temperature inversions in conjunction with large quantities of particulate matter and moisture can increase the severity of local ice fog conditions. The proposed 30,000 horsepower compressor stations would each produce 7,200 gallons of 600°F water vapor per hour. This source of moisture would be adequate for the formation of ice fogs in the immediate vicinity of each compressor station given the additional criteria previously described.

The impact of the ice fog would generally be micrometerological, that is site dependent. Extended periods of temperature inversion conditions combined with large amounts of particulate matter and moisture in the air can produce ice fog that gradually becomes denser and which persists for several weeks.

The direct impact is a serious reduction in visibility. It is primarily a safety hazard. By reducing visibility below safe operating levels for aircraft and surface travel, ice fog would effectively isolate compressor stations and nearby camps and communities; thus in effect delaying and in some cases stopping all operation and maintenance activities on substantial mileages of the pipeline.

Construction schedules are designed to take advantage of Alaska's climatic conditions by doing most of the heavy construction during the long winter season. It is estimated that construction of the pipeline from the initial mapping and surveying through the mid-project years pipe-laying activity through the late-project years installation of the compressors and the final year start-up of the gas through the pipeline will require a total of 6 1/2 project years. The pipeline route has been divided into six, nearly equal work sections, or "spreads" as follows:

I	137 miles	MP 0 Prudhoe Bay	MP 137 Galbraith Lake
II	133 miles	MP 137 Galbraith Lake	MP 270 Prospect Creek
III	143 miles	MP 270 Prospect Creek	MP 413 Wickersham Dome
IV	147 miles	MP 413 Wickersham Dome	MP 560 Darling Creek
V	158 miles	MP 560 Darling Creek	MP 718 Mosquito Creek
VI	91 miles	MP 718 Mosquito Creek	MP 809 LNG Plant (Gravina)

Each spread will be self-sufficient with its own work force, camps and headquarters, construction equipment, and support facilities.

A high percentage (estimated at 87 percent) of the pipeline route passes over permafrost. Working over permafrost presents many engineering and environmental problems. In order to prevent or reduce the degrading effect construction activity would have on the integrity of the permafrost regime by scarring or disturbing the vegetative mat and the active layer winter construction using roads, pads, and other work areas made of snow and ice is planned.

The winter season varies slightly between work sections, but generally runs from October to April or May. With the exception of a few short sections of pipeline where unusual geologic or topographic conditions exist or extremely harsh weather conditions occur, construction will be done in the winter during two seasons from October in project-year three to November in project-year five. Approximately 85 percent or 683 miles out of the total of 810 miles of pipe will be installed during the winter.

Engineers and others planning construction schedules have estimated the number of days in the winter season and have arrived at the net work days potentially available during the two winter seasons by deducting days for the total darkness and extreme cold. These are shown in Table 8.2.1.-46.

It is difficult to tell whether or not the estimates in the Table of the daily requirements for distance of pipe to be laid and the net number of work days available during the two winter periods are realistic. Practical experience in the construction and installation of a pipeline in the permafrost under Arctic winter conditions is virtually non-existent. Certainly the concept is desirable since if it is successfully implemented it should be a major factor in reducing the degrading effect of construction activities on the integrity of the permafrost as compared to construction during the summer thaw period. However, since virtually the entire length of the route is subjected to extremely severe cold characterized by extended periods of total darkness (night) and constant, well below zero temperatures, successful completion of the winter work on schedule appears highly questionable. Men and equipment will be subjected to interminable periods of extreme cold under nighttime conditions. It is almost certain that the bulk of the construction work time during these extended periods of severe Arctic cold will be spent in keeping warm and in keeping equipment running. The struggle for survival will dominate the workers' thoughts and actions and work on the pipeline will come out a poor second.

The severe cold combined with the long winter night (total darkness for several weeks) tends to have a demoralizing effect. Workers will be hesitant about leaving, warm vehicles and other shelter for even a few seconds in the course of construction activities. And when they do venture out their work efficiency will be drastically reduced by the bulky clothing and clumsy gloves so necessary for survival. On many occasions it will actually be unsafe for construction to continue and it will be necessary to reduce or even halt construction activities for significant periods of time.

Thus the impact of the Arctic winter on the project is the most important factor in controlling the completion of the work as planned. In any event if severe Arctic winter conditions prevent completion of work during the time the snow pads and the ground is frozen, equipment that is not removed to permanent gravel work areas will become mired in the active layer during the summer thaw. Retrieval of equipment will cause permanent damage to the insulating capacity of the active layer and accelerate thawing and erosion of the permafrost. Additional gravel will be required to build access roads and parking areas for equipment. If the winter plan is dropped or modified in favor of more summer construction major impacts such as the depletion of gravel resources, downstream water-quality degradation, change in stream hydrology, loss of crucial fish and wildlife habitat such as spawning grounds for fish and winter browse furnished by the riparian willows for moose will occur, and of paramount importance will be the impact of various types of activities on the integrity of the permafrost regime.

Any extension of the work schedule beyond the time frames proposed will have a significant impact both on the environment and on people. In the first instance additional construction time means inevitably that additional damage will occur to the active layer which serves to insulate the permafrost. In the second instance a delay in completion of the pipeline means a delay in the delivery of energy in the form of natural gas.

Weather problems aside, the winter pipeline construction concept has two major factors in its favor. One, it would be more desirable than a summer construction program due to its very low requirement for gravel from sources already seriously depleted in many locations along the corridor by the Aleyeska Oil Pipeline construction activities. Two, the winter method is believed to be less of a threat to the integrity of the permafrost regime if it can be implemented within strict time constraints. However, due to the many unknowns associated with the winter concept more information is needed. The Department of Interior, ANGTS - A Report to Congress -A Feasibility Study, 1975, doubts that the winter construction schedule can be met. The estimates and information presented in Table 8.2.1.-46 regarding the number of work days available during the winter season, the length of the winter season, and other data can only be considered as preliminary in nature. Due to the potentially beneficial aspects of the winter concept it merits high priority consideration including the immediate initiation of a thorough analysis of climatic, geologic, and engineering factors related to the concept.

Gravina LNG Site--No significant impact on climate is expected from the LNG plant.

Topography--

Pipeline--Some landscape changes in topography would be caused along this alternative route by borrow areas, ditch mounds, buildings, and ports. Borrow areas would be in streams, active and fossil flood plains, sidehills, on level land, and in exposed bedrock quarries. The impact of the excavation of borrow materials for the alternative pipeline on topography and landscape would be local. Many of the same areas would have been used for construction of the Alyeska oil pipeline, and visual impacts and changes in topography would be cumulative. In some cases, because of the possible size and location of borrow areas, visual impacts would be considered adverse by people viewing the area.

A backfill mound would cover the proposed pipeline along the entire route. The visibility of the mound depends upon the variability of the surrounding land surface. The overall visual impact of the backfill mound on the existing topography is considered to be slight and incremental because of the road, oil pipeline, and other man-made intrusions which would already exist along this route. The primary topographic problem caused by the backfill mound is the alteration of the microrelief of the land surface. This alteration of the microrelief can have a significant effect on the localized drainage, encouraging waterflow alongside the mound until a reversal of slope is reached. Additionally, the lack of surface roughness due to less-developed vegetation or smoothing by construction operations would induce waterflow alongside the backfill mound even though drainage crossover breaks are provided. Erosion resulting from this drainage disruption could have a greater effect on local topography than the mound itself.

Table 8.2.1.-46 Estimates for construction of pipe ditch and installation of pipe, during two winter periods.

Pipeline Section	Winter Period	Total Work Days	Days Lost to Darkness and Extreme Cold	Net Work Days	Total Miles of Pipe: Winter Construction	Total Length of Pipe in Feet	Average Daily Work Requirement: Number of Feet of Pipe
1	October-May (210 Days)	420	156	204	137	723,360	2,740
2	Late October-Late April (180 Days)	360	101	259	130	686,400	2,666
3	Late October-Early April (170 Days)	340	80	260	143	755,040	2,901
4	November-March (150 Days)	300	80	220	147	776,160	3,528
5	November-March (140 Days)	280	70	210	118	623,040	2,967
6	Summer construction except for river crossings and scattered muskeg areas				8		
				Total	683		

Permafrost alterations initiated by the proposed pipeline could cause the development of surface features such as pingo mounds, thaw lakes, and thermokarst pits, which ultimately alter the local topography.

The last segment of the 810-mile route leaves the Alyeska corridor in the Lowe River basin a few miles east of Valdez (at mile 767) and proceeds southerly 46 miles through the Eastern Prince William Sound Unit of the Chugach National Forest to Gravina Point on Prince William Sound. This is wild and rugged mountainous country with the upper elevations composed of open alpine tundra interspersed with glaciers producing streams which cut deep valleys in their short journey to the Sound. The lower valleys are forested. Pipeline construction and installation of permanent facilities will cause an adverse impact on the aesthetics of topography which was perviously unscathed by man's activities.

Gravina LNG Site--Impact upon the onshore topography of the site would probably be limited to areas where grading is required. The existing land surface at the proposed location of the liquefaction train ranges from 100 to about 225 feet in elevation. In order to grade this to a level surface, cuts of up to 75 feet could be expected while the downhill (eastern) portion would have to be raised about 50 feet. The final grade under the LNG tanks would be 148 feet whereas this area presently ranges from 100 to 200 feet in elevation. Cuts of about 10 feet would be necessary for the impounding area and sump, and the southern border of the tank and sump area would be formed by a dike which would be at least 10 feet high.

The area's topography could be further altered at borrow pits. If borrow activity is required, the applicant has proposed to develop aggregate sources at the mouth of Simpson Creek or the Rude River.

Geology--

The interaction between the possible construction and operation of the proposed Prudhoe Bay to Point Gravina Gas pipeline and the geologic environment is considered in this section. There are also geologic factors which would affect the pipeline. For example, a pipeline would not affect the seismicity of an area; however, an earthquake could cause a pipeline rupture, which in turn could have a significant impact on the environment.

Mineral Resources--

1. Pipeline. The construction and operation of a gas pipeline would have little, if any, impact on the development of the mineral and energy producing industries except oil, gas, and aggregate (sand, gravel and quarry rock). Gravel in particular is in short supply along this proposed corridor because large amounts are being used for the construction of the Alyeska oil pipeline. The highways and oil pipeline have put heavy demands on this scarce commodity and the proposed gas pipeline would require approximately 6.5 million yards of gravel. In many areas the old and new riverbeds are the only source; consequently, as gravel requirements increase, the stream hydrology and water quality are also adversely affected.

Other potential oil provinces crossed by or close to the proposed pipeline include the northeastern end of the Yukon-Koyukuk province (Patton, 1971), the Yukon Flats, and the Copper River Basin (Gates, et al. 1968). The Gulf of Alaska or Pacific Margin province encompasses much of the onshore area to the east of Prince William Sound and the offshore area in the Gulf of Alaska. The presence of both an oil and a natural gas pipeline could make development of these other reserves more attractive.

Experience in large oilfields elsewhere in the world indicates that the development of the Prudhoe Bay field would lead to extensions and to new discoveries nearby. Unless restricted by regulation, classification, or policy of some type, expansion of the oil producing part of the Arctic Slope oil province is to be expected. Thus, the operation of the pipeline system would lead to the extraction, transportation, and use of an unknown quantity of oil and gas in excess of the known resources of the area traversed by the pipeline.

Increased access into the area north of the Yukon River and east of Valdez could increase exploration for, and because of better transportation facilities, exploitation of other mineral resources such as coal, heavy metals, and geothermal resources.

2. Gravina LNG Site. The site area is within a region with high potential for gold, silver, copper as well as other minerals. If the bedrock beneath the site were to contain such materials, they would be rendered inaccessible for the lifetime of the proposed facilities.

Permafrost--

1. Pipeline. Permafrost is a critical geological, climatological phenomenon central to this environmental impact statement. Permafrost is maintained by a sensitive thermal balance. Natural disturbances such as lake drainage, fire and solifluction upset this delicate heat balance. Human activities include disruption of the vegetative mat by vehicular traffic, placement of structures, and excavation. The thickness and general insulating qualities of the organic layer and the ice content of the uppermost permafrost layers are critical in determining specific impacts.

All disturbances in permafrost areas would have long-term effects on the permafrost regime. Short-term effects result from major activities during construction phases when the surface organic mat is pulverized or removed and ice-rich soil is exposed to direct radiation sun and/or new sources of water. Modification of the heat balance usually causes degradation of the permafrost layer. If a high-ice content area is involved, subsidence, slumping, gullying and establishment of new drainage patterns occur. Once initiated, permafrost degradation is difficult to arrest until a new heat balance is achieved. Disturbances are slow to revegetate naturally because of shortness and coolness of summer. Continuing erosion also adversely affects natural revegetation.

The temperature of the permafrost in an area is indicative of its ability to stave off degradation. In the lowland area north of the Brooks Range, the temperature of permafrost at depths just below the zone of seasonal variation generally ranges from -11° to 5°C (about 12° to 23°F). In lowland areas south of the Brooks Range, the permafrost temperature generally is warmer than -5°C (about 23°F). Within mountainous areas (e.g., Brooks Range, Yukon-Tanana Upland, Chugach and Alaska Ranges), the temperature is extremely variable.

Natural gas would be introduced in the line at a temperature below 32°F (0°C) and above the dew point of the gas. Compression and refrigeration of the gas would take place at regular intervals along the entire length of the pipeline. The purpose of refrigerating the gas is to prevent large-scale and long-term degradation of the permafrost regime along the pipeline.

Because the gas would be refrigerated, it is estimated that a frost bulb of unknown size would develop around the pipe. The size of the frost bulb would depend on the specific temperature of the gas, the permeability and porosity of the surrounding soil, and the water content of the soil. Although studies have been done on the effect of chilled pipeline in the soil, they have been of too short duration to predict the long-term heat balance between surface temperature, the frost bulb, and adjacent soil. Industry has not demonstrated that a buried, chilled pipeline can be operated safely in the permafrost region, especially in the discontinuous permafrost zone.

Unless specification is taken as described in Alaska, chapter 3, a major impact of the pipeline on permafrost would occur in the time period from the initial disturbance until the initiation of chilled operation. Portions of the pipeline could be buried in excess of 2 years before the introduction of the chilled gas. Work by the Russians on underground pipelines in permafrost regions indicates that unchilled pipe could be lifted out of the ground during the winter because of frost heaving and other natural forces. More recent work done by Alaskan Arctic Gas Pipeline Company (Alaska, chapter 3) suggests that the use of a surcharge (berm) will mitigate this effect, provided that berm erosion and subsidence effects are considered.

Thus, there are two impacts of the proposed pipeline which must be mitigated to the greatest extent possible--the initial effect of the construction effort and the subsequent waiting period.

Frost Heave--

1. Pipeline. Frost heave is caused by the difference in volume between frozen and unfrozen water. Frost heave, or expansion of the soil profile through ice formation, is possible where three conditions exist: frost-susceptible soils; a source of water; and freezing temperatures. With the proposed buried, chilled pipeline there would be a tendency for pore water (ground water) to migrate toward the advancing freezing front of the frost bulb. The pipeline system would provide the freezing temperature; while the backfilled ditch may provide local favorable-susceptible conditions. The pipeline is proposed to be buried below the active layer in perennially frozen soils.

The impact of frost heave upon the pipeline would depend on the severity of the heaving. Uplift of the pipe gradually through an area, especially in a floodplain or riverbed could result in its uncovering and exposure to erosion. Differential uplift on the pipeline would place increased stress on the pipe. In either case the primary environmental impacts would be in the construction effort required to repair or replace the pipe. If the pipe had been stressed to the point of failure after the initiation of gas transmission an additional safety hazard would be added to the repair work. The effect of the repair effort would be similar to that of the original construction impact on vegetation, soils, permafrost, and erosion.

Erosion and Mass Wasting--

1. Pipeline. Erosion and mass movement are geological processes which operate using the force of gravity, the former with water or wind as the principal medium and the latter with the entire body of soil and rock debris (water-saturated) as the medium. Consequently, the severity of these processes increases as the slope of the land surface increases. The

proposed pipeline route passes through some of the most rugged topography in Alaska, traversing many steep slopes along the route in the Brooks Range, the Alaska Mountain Range, and the Chugach Mountains as well as in some foothills and plateau regions. Whether the pipeline route crosses the land surface parallel to the slope, oblique to the slope, or perpendicular to the slope, the construction effort would upset the equilibrium of the soil mass. Even in rolling terrain, ice-rich soils would be very susceptible to erosion and mass movement since slope stability in permafrost is very sensitive to the amount of water in the soil. Surfaces of as little as 3 percent slope have had significant downhill movement of soil material in permafrost areas.

Thawing of permafrost caused by construction or maintenance activities could result in slope failure, especially where fine-grained, ice rich soils are encountered. As melting of interstitial ice (thaw consolidation) takes place, the volume of the thawing soil profile is reduced. If water is generated at a rate exceeding the discharge rate of the soil materials, the total soil mass may behave like a liquid.

Thaw consolidation must be considered as an annual event which takes place rapidly. Slope instability could be expected to occur throughout the operating life of the pipeline system. This would probably occur during the early summer necessitating repair work when the surface is thawed. Thaw consolidation would be caused by construction and operation of this pipeline and would in turn adversely affect the line.

Solifluction, defined as a shallow, downslope movement of water saturated unfrozen sediments over a surface of frozen material, is probably the most frequent evidence of slope instability on the tundra of the Arctic Coastal Plain and Arctic Foothills. It differs from other forms of slope instability, such as creep and rockslides, in that entire sheets or lobes of unconsolidated sediment move. Limited to periods of thaws, solifluction is a condition caused by the impermeability of permafrost and low evaporation rate. Downslope movements might be so rapid that a structure resting upon the area of movement will either be subject to large earth pressures or move passively downslope.

A shallow, downslope movement of soil and tundra vegetation, such as solifluction, probably would not affect the buried portion of the pipeline system. However, it could redirect surface drainage, accelerate erosion, and thaw permafrost. The impact of slope instability conditions is considered significant since slope failure would require repair and stabilization when the surface is thawed and is most susceptible to vehicular damage from repair activities.

Slope failure would ultimately affect pipeline integrity, therefore, slope repairs would be required as failures occur. The necessary repair and stabilization would have to be accomplished when the active layer was thawed and most susceptible to damage. Significant impacts such as disruption of vegetative cover, degradation of permafrost and enhanced turbidity and loss of water quality in streams draining the area, would result.

"Skin flows" involve the detachment of a thin veneer of vegetation and mineral soil and subsequent downslope movement in the form of long ribbon-like tears in the surface vegetation which sometimes coalesce into broad sheets. Skin flows can occur on both steep and low angle slopes. It is probable that construction of the pipeline project would increase the occurrence of skin flows where the surface vegetation is disturbed. Secondary impacts from new skin flows could be major in that the heat balance controlling permafrost would be disrupted. It is probable that thermal consolidation would increase on such areas which in turn could cause either deep-seated creep or solifluction. Because this "skin flow" is shallow, it probably would not affect pipeline integrity except indirectly unless surface drainage is redirected. Impacts from skin flow are considered to be similar to those from solifluction in that movement of construction equipment during summer repair work could produce major impacts when the surface is thawed.

Deep-seated creep or mass wasting might occur in permafrost slopes where the underlying permafrost is warmed but not thawed. Under such conditions even thick deposits of materials may move farther down slopes. Along the pipeline ditch local conditions might be favorable to deep-seated creep. The matter for concern is the slope-pipeline interaction since deep-seated creep can cause movement of the pipeline. The impact of deep-seated creep causing pipeline failure would be significant, major, and adverse since the system could not deliver natural gas. Impacts to the local environment would be similar to those described for solifluction and skin flows if summer repair should be required.

The impacts of the pipeline on slope stability could be very significant, particularly in sloping ice-rich soil areas. Although impacts would be local, their proximity to water courses (where terrain is steepest) can have major secondary impacts on water quality through increased siltation. A tertiary effect resulting from slope instability would be to upset the heat balance controlling the underlying permafrost.

Coastal and Marine Related Erosion and Deposition--Two coastal regions are involved--the Prudhoe Bay area of Beaufort Sea on the north and the Prince William Sound area of the Gulf of Alaska on the south end of the pipeline.

Beaufort Sea and Prudhoe Bay would be little affected by the project with the exception of some deposition of silt and sediment which would be incremental to the deposition from the Aleyeska oil pipeline construction activities along the Sagavanirktok River.

The pipeline crossings in the interior of Alaska of several major rivers drainages which empty either into the Bering Sea or the Gulf of Alaska would cause some localized siltation and sedimentation but would have little or no impact on marine waters. This is due to the tendency of these rivers to deposit excess sediments on their floodplains long before they reach the sea.

However, the northeast quadrant of Prince William Sound merits special consideration. Here, the gas pipeline emerges from the Chugach Mountains and enters the Prince William Sound drainage by following a stream several miles down to the head of Port Fidalgo Bay. Then it proceeds easterly along the shore of Prince William Sound and up the Gravina River, swings over a height of land and down another stream to the head of Beartrap Bay, skirts Port Gravina Bay crossing Comfort Cove and then proceeds southerly across the height land to the LNG terminal site on the south side of Gravina Point on the north shore of Sheep Bay.

Preconstruction operations such as clearing and stripping, construction activities such as trenching and back filling, and operating activities such as fuel and other toxicant handling and storage could have major adverse effects on the estuarine areas of Prince William Sound that are near the proposed gas transmission facilities.

The Chugach Mountain-Prince William Sound region is characterized by high precipitation--approximately 90 inches annually with heavy snowfall in the winter and heavy rainfall in the summer. Since most of the construction on this segment of the gas pipeline is scheduled for the summer season there would be an increase in erosional processes because of the unprotected ground surfaces and the large amount of precipitation that falls in the area. This will increase the silt content of streams and estuarine areas to the detriment of freshwater and marine organisms.

This increase in waterborne silt would increase the buildup of bottom sediments which will smother some of the bottom dwelling organisms, eggs, and attached young of other free-swimming organisms.

Since most of the siltation and sedimentation would occur during the peak (summer) of the growing season and reproductive cycle for many forms of aquatic animals living in the marine waters and coastal streams of the Sound the impact although of short duration could have severe adverse long range effects. Growth rates of young and adults alike could be severely retarded and quite possibly the reproduction of a species could be reduced or even prevented, thus removing or seriously reducing a particular age class. The small streams bordering the Sound support spawning runs of valuable anadramous fish species such as salmon. These runs could be delayed, reduced in intensity or even stopped by the disturbances of construction activities.

Seismicity--

1. Pipeline. Available information on seismicity has been covered in the preceeding descriptive section on the environment. Earthquakes of magnitude 6 on the Richter Scale and larger are potentially destructive, and earthquakes of magnitude 5 may cause local damage.

The seismic zonation applied to the Alaska oil pipeline, which now is being built along most of this route is also applicable to a chilled, buried natural gas pipeline. The zone north of latitude 67°N (south slope of the Brooks Range north across the north slope to Prudhoe Bay) has a history of seismic activity well under the magnitude of 5.5 on the Richter Scale, south of latitude 67°N is a different matter. Large segments (mileages) of the route have a history as well as a potential for severe and destructive earthquakes ranging from magnitude 6.5 to 8.5 on the Richter Scale.

The route intersects several recognized major faults in the four seismic regions south of 67°N latitude; however, except for the Denali Fault, which displays abundant geologic evidence of a large Holocene offset (Richter and Matson, 1971). The risk of significant tectonic movement of these faults is essentially unknown at present. Many additional faults are also postulated to exist, particularly in the segments 67°N to Donnelly Dome and Willow Lake to Valdez. Both of these segments are characterized by the frequent occurrence of sizable earthquakes that have yet to be identified with individual faults.

The occurrence of large earthquakes is a potentially serious hazard to the integrity of the pipeline system. Seismic shaking or surface faulting accompanying a large shock could rupture the pipeline directly or cause failure in the foundation material that could lead to rupture. Furthermore, large earthquakes could trigger landslides and sea waves that could jeopardize the integrity of the pipeline, the LNG plant, loading dock, and tankers.

The immediate impact of a pipeline failure resulting from an earthquake would stem from the loss of natural gas. Environmental impact would be situation dependent. The most serious direct impacts would stem from a fire. Destruction of the vegetative cover could result in disruption of the thermal regime and erosion. Because of the implication of fire in relation to a gas pipeline control measures would be instituted immediately. The experience in Alaska has been that fire suppression usually causes worse environmental impact than a fire. (Slaughter, et al, 1971). The primary concern here would be the loss of vegetative cover, the disruption of the soil thermal balance where this is a problem and the resultant erosion. Repair of damage to the pipeline would have a similar impact. All of this impact while the indirect result of the fire would stem directly from the use of heavy equipment in suppressing the fire and making repairs.

2. Gravina LNG Site. Potential impacts upon the facilities by the environment are mainly earthquake related, and include ground shaking, ground rupture, landsliding or slumping, displacement, soil liquefaction, and tsunami generation. As has been mentioned in the section on existing environment, there is disagreement or, more accurately, a lack of data concerning the existence of faults on Gravina peninsula. Moreover, there is, to date, very little information pertaining to the activity of the faults which are known. Because of the possibility of the existence of a fault within 2 miles of the property proposed for construction and the fact that this area is on the strike of the major faults involved in the 1964 event, it would be unwise to discount the possibility of ground rupture at the site.

The applicant has proposed to design the facility to withstand 0.6g of bedrock acceleration without loss of fluid from the storage tanks or processing equipment. An acceleration of 0.3g would be used for other components of the facility. The higher level of shaking could result from an 8.5 magnitude event at an epicentral distance of just over 20 miles. It is not unlikely that such a combination of distance and magnitude would occur during the lifetime of the facility.

Ground rupture at the site may not be ruled out. The existing data does not deny the possible existence of a fault at the site. Absence of such a fault does not mean that rupture could not take place. Secondary faulting with 6 feet of offset could be expected to occur within 10 miles of the main fault associated with an event of magnitude 8.5.

Due to the low slope of the site and the proximity of bedrock, it may be surmised that the potential for earthquake induced landsliding or slumping is low. The accuracy of this assumption must be tested by foundation studies.

Tectonic displacement of the site area as a result of the 1964 event was shown to be substantial. The plant site was raised about 4.5 feet and translated 30 feet to the southeast (Plafker, 1969) in response to the regional thrusting. The earthquake epicenter was about 55 miles away.

Tsunamis or seismic sea waves generated during the 1964 event had runups within Prince William Sound of 50 to 75 feet. A runup of 100 feet and wave heights of 65 feet have been postulated as being associated with the design event (Dames and Moore, 1973). The onshore facilities would be at a sufficient elevation to avoid damage from such a wave. A wave generated outside of the southern Alaska area would probably be noticed sufficiently in advance of its arrival to allow a tanker to be removed from the vicinity of the marine facilities. In the event of a wave being generated in or near the sound, it is unlikely that a berthed tanker could be so removed. It is possible that the vessel and terminal facilities would be destroyed by the design wave if the ship were still berthed.

Glacial Impacts--

1. Pipeline. The section of the Brooks Range which would be traversed by the proposed pipeline is free of glacial ice, except for a few small glaciers on the north-facing slopes of the higher mountains. Thus, no impact or interaction with glaciers is expected in the Brooks Range. Further south, however, the proposed pipeline route would pass adjacent to the termini of the Worthington Glacier in the Chugach Mountains and the Black Rapids, Canwell and Castner Glaciers in the Alaska Range.

The Black Rapids Glacier displays patterns corresponding to the quiescent and active phase of a surging glacier. Indications are that the buildup for the next surge is proceeding; however, the timing and probable amount of the advance of the surge is unknown. Canwell and Castner Glaciers are characterized by conditions indicating either a continuing retreat of the ice front or near-equilibrium conditions. Canwell Glacier, however, has a sinuous moraine ridge that suggests periodic surges on one of its large tributaries.

The Worthington Glacier has been in retreat since 1937. The terminal lake, now 800 feet long, was just beginning to form in 1953. This would suggest a rate of retreat of about 40 feet per year. Neighboring glaciers show a similar history of retreat.

Surficial geologic deposits downvalley from the terminals of these glaciers show that their active ice fronts have reached or crossed the Alyeska pipeline alignment within the past 300 to 350 years. The proposed natural gas pipeline route is on the side of the Alyeska pipeline alignment away from these glaciers. Therefore, the proposed pipeline would be less vulnerable than the Alyeska pipeline to damage by the possible advance of these glaciers. The proposed route is not far enough from the former terminuses to eliminate all possibilities of damage by a surging advance of one or more of these glaciers.

See also the discussion of the potential impact of the Columbia Glacier on navigation covered in the marine route impact analysis section.

Soils--

Pipeline--This LNG alternative pipeline project would require excavation of a ditch approximately 800 miles long. Materials excavated from the ditch would be placed on a packed snow pad or in the event of summer construction, on vegetation growing alongside the ditch until the pipe has been laid into place. At that time, some or all of the spoil material would be used as backfill to cover the pipe. The process of excavation, storage, and replacement would result in considerable mixing of the soil. Secondary impacts as discussed below could adversely affect the success of revegetation over the pipeline. The extent of this impact is unknown. (See discussion on vegetation.)

It is probable that all spoil stored along the open ditch would not be removed during the backfilling process. Soil left on top of the native plants would have secondary effects by changing soil temperature (dark soil absorbs more heat than light soil potentially upsetting the natural heat balance) and by smothering plants.

Indications are that as much as 6.7 million cubic yards of borrow material would be used for construction purposes. Some would be used for gravel pads, some to replace ice-rich soils which cannot be returned to the ditch and some for pipe bedding material.

Excess spoil tentatively has been proposed for disposal in borrow sites which supplied the new backfill material. Transporting ice-rich soil materials to new locations could have major local impacts if these ice-rich materials thawed and reached rivers, streams, or lakes as mud or if they became a source of dust.

Unknown quantities of fuel and lubricants would be used during construction of the pipeline project. Spills would occur and all spills would not be removed completely before they have contaminated the soil. If a spilled petroleum product percolates into the soil, it could kill vegetation and contaminate groundwater supply. The extent of groundwater contamination would depend on the type and volume of spilled product, the presence or absence of impermeable compacted snow or frozen soil, the permeability of the soil, the depth of the water table, and the flow rate of the groundwater.

The most severe impacts to ground water would occur where the water is close to the surface and the soil is permeable. Most of the soils along the route are coarse enough to allow passage or spilled petroleum products.

In areas where the permafrost is not present (Prince William Sound drainage) spilled pollutants would penetrate to deeper soils which could adversely affect groundwater and vegetation over a large area.

The process of biodegradation of a spilled petroleum product in the soil depends on the presence of oxygen and adequate plant nutrients. Nutrient availability in arctic soils appears to be related to soil temperature. It has been shown that nutrient levels decrease with lowering soil temperature. Thus in those areas where the chilled pipeline lowers the ambient soil temperature a reduction in soil nutrient availability would occur with a subsequent reduction in the growth rates of vegetation (see discussion on vegetation).

A spilled petroleum product could remain in the subsoil for years because of the low temperatures, low amounts of available nutrients, and excess soil moisture found in many of the subsoils along the route. Low temperatures and low amounts of available nutrients would impede the bacterial activity responsible for the biodegradation of the spilled petroleum product. Excess soil moisture would inhibit the decomposition process because oxygen diffuses through petroleum products more rapidly than through water. The rate of biodegradation could be increased by turning and mixing the soil to aerate it and by adding fertilizer, especially nitrogen and phosphorus.

The gas pipeline passes through many miles of potential agricultural soils in the Yukon, Tanana, and Copper River Valleys where these soils are largely undeveloped. There has been some homesteading, but there are few producing farms. Making natural gas available as a source of energy for processing of agricultural products would be a positive impact to the industry. Increased access to the potential farm areas also would have a positive impact on the industry.

Water Resources--

Pipeline--The pipeline would cross approximately 550 streams of which 20 have drainage systems of more than 1,000 square miles. Among the largest are those of the Koyukuk, Yukon, and Tanana Rivers.

Although there are no reliable long-term water quality data for most of the project area, the present wilderness condition, the low light level of human use, and the limited data available suggest that water quality is good. This is not to say, however, that the water is "pure." Large concentrations of waterfowl adversely affect water quality at lakes during molting and staging periods. Similarly, streams carry heavy sediment loads during periods of high runoff and glacier-fed streams carry heavy sediment and bed loads during the summer.

A significant aspect of stream hydrology north of the Yukon River is the fact that there is a virtual cessation of flow within stream channels during the winter. In a large number of streams the only winter water flows occur as ground water movement in the aquifer under or adjacent to the solidly frozen channel. This magnifies the severity of impacts which do occur.

Arctic and subarctic streams would be dewatered by the use of existing stream flow or groundwater flow as a source of water for construction during the winter. There would be a direct impact on fish overwintering in springs, overwintering fish eggs and on other aquatic organisms. This would occur because of the loss of water and associated loss of oxygen.

The construction of the pipeline, access roads and support facilities would result in local alteration of surface drainage patterns. Such alterations would create new areas of wet and dry conditions. Secondary impacts of concentrating or redirecting surface drainage could result in increased local water quantities and velocities. These concentrated drainages would result in both thermal and surface erosion.

Snow/ice roads would also affect surface drainage. These roads would melt more slowly than adjacent areas and, accordingly, would temporarily block surface flow. In the arctic tundra, construction and use of these roads would also cause compaction of the vegetation mat and underlying soil. This compaction would cause depressions where surface water would start to flow. Increased flow could result in the formation of new drainage patterns.

Construction in streams would increase the sediment load. This would impact fish overwintering in high concentrations in springs. A substantial amount of the increased sediment load could be organic detritus. An increased biological oxygen demand (BOD) would be the result. This could be very significant if dewatering and increased sedimentation occurred at the same time.

Another source of increased BOD is the fertilizer that would be used to reestablish, vegetative cover in the construction zone. Again the critical node in the stream ecosystem would be concentrations of overwintering fish in springs. Overwintering eggs would also be affected.

An estimated 6.7 million cubic yards or more of gravel and fill would be required during construction of this project. Most of this material would be gravel taken from active and fossil flood plains. This would have a serious impact because it would be the third major construction project along portions of the route; the other major projects being the Aleyeska pipeline and haul road. In the Gulkana Basin the gravel supply is inadequate for construction of the oil pipeline. In the Sagavanirktok River Valley the construction of the road has seriously depleted the gravel resources in several areas. The gravel requirement for construction of the oil pipeline will very likely carry the total gravel commitment beyond reasonable and acceptable limits in some areas. The gravel requirement for the gas pipeline would further stress the stream systems supplying the gravel. The ability of the stream flood plains to supply this gravel without sustaining serious, irreparable damage is probably one of the key environmental issues affecting any decision to select this route.

Large scale removal of gravel could result in accelerated and magnified streambed shifts until equilibria was reestablished. This could cause disruption of aquatic life and spawning beds and could increase sediment transport.

The two-winter pipeline construction schedule concept (see Climate Section) poses serious threats to the environment if schedules are not met. Extension of work into a third winter, more summer work, work during the transition from winter freeze conditions to summer thaw conditions and so on will add to gravel requirements. This in turn would magnify impacts on stream hydrology and aquatic and riparian animals and their habitats--for example, destruction of spawning grounds for fish and the loss of willow browse for moose.

The estimate of 6.7 million cubic yards of gravel may be way under actual needs with an estimate of several times this amount (such as 30 million cubic yards) well justified. Certainly experience on the Aleyeska project verifies the difficulty in making accurate predictions of gravel requirements. The original project design for the Aleyeska project was for 67 million cubic yards of gravel, however, this did not include gravel needs for the haul road, three airfields, and the river training structures. By mid-October, 1975 the Aleyeska oil pipeline was estimated to be 50% completed. Total gravel consumption to that time was 78.9 million cubic yards with 23.5 and 55.4 million cubic yards used for the haul road and the pipeline, respectively. Even if the pipeline work pad and work areas have been completed additional gravel will be required for road maintenance and to bring pads and other areas up to grade where subsidence and other erosive actions have caused the gravel to settle.

It is estimated that as of mid-October, 1975 there were 185 million cubic yards of gravel left in the 382 material sites approved for Aleyeska use. Approximately one-half of these are located in the active flood plain. Future gravel requirements have already been intensified by heavy road maintenance demands due to Aleyeska trucking activities. Irrespective of the gas pipeline trucking, it is estimated that during the active life of the Aleyeska construction the 367 miles of the haul road from Yukon to Prudhoe, for example, will require 1500 cubic yards of gravel per year per mile, approximately one-half million cubic yards per year total, to maintain the road to secondary state road standards. Heavy truck traffic has also had a major impact on public roads south of Livengood along the Aleyeska route to the extent that the State of Alaska is seeking Federal Aid funds for repairs. This will involve an unknown but certainly a significant amount of gravel.

The need for a thorough analysis of gravel resources and requirements before final approval of the gas pipeline seems obvious. This analysis should merit top priority and should consider comparisons between requirements and availability and location of gravel resources with various combinations of pipeline construction schedules such as all winter, all summer or combination summer and winter construction.

Operational impacts on surface water could result from the development of a frost bulb (mass of frozen soil surrounding a pipe containing gas at a temperature of below 32°F) at stream crossings.

The frostbulb could block groundwater flow under the stream and could lead to the formation of an ice anchor across the stream which would restrict surface flow within the stream. In winter this blockage could result in forcing the groundwater and streamflow up onto the surface of the ice causing icings and dewatering of the stream. Fish, fish eggs and aquatic organisms would be impacted by the water depletion downstream of the blockage. Icings could have secondary effects of forming a surface ice dam which would redirect surface drainage patterns. Formation of an ice dam would be conducive to stream channel modification; it could enhance ice scour; and it could affect, as a secondary impact, streambank slope stability.

The ice dam would also force high water flows out of the active stream channel. This would result in enhanced meandering in braided channels and stream bank erosion in regular channels. The net result would be increased sediment transport and a corresponding drop in water quality. Ice scour during spring breakup would aggravate the problem. This impact would be in addition to the impact of the borrowing of gravel which would take place during construction.

The ice dam would also accelerate down stream scour. The resulting down stream pool could be beneficial to fish but this is by no means certain. The pipeline would tend to interrupt or direct surface water either impounding it or causing erosion by diverting it.

The ice roads used in construction would create similar blockage and diversion problems in the first year. There would also be residual erosion problems which would add to sediment loading in local streams.

Increased BOD can be anticipated in streams draining camp areas. Eutrophication would be enhanced in most standing water adjacent to camps in the Arctic.

Minor spills of fuel, hydraulic fluid, and lubricants would occur along the entire pipeline route as part of the routine fueling and maintenance of construction equipment. Repeated small spills of fuels and lubricants along the proposed pipeline route could be as serious a water quality problem as a single large spill.

The probability for major spills of fuels, lubricants, or toxic materials at storage sites and during water transportation along the Alaskan Arctic Coast and in Prince William Sound cannot be discounted. Should a major spill occur, there would probably be long-term adverse impacts on water quality since adverse weather and ice conditions would hamper any remedial actions.

Repair of the proposed pipeline could cause serious, major impacts on water quality. Repair during winter months would produce impacts on water quality similar to those described for construction. Repair required during summer periods would create significant impacts on water quality since construction equipment would cause disruption of the vegetation through compaction at a time when water could readily cause erosion. The primary impact on water quality would be an increase in turbidity. Fuel and lubricant spills associated with repair activities would also adversely affect water quality. The impacts of reduced water quality from repair operations would depend upon time of year, repair location, how far equipment must be moved, and the type of soil and water conditions encountered during transport and repair procedures.

Ground water conditions along the gas pipeline are highly variable, primarily because of permafrost.

The impact of the heavy equipment and supply surface movements on groundwater drainage might be significant in that the thermal balance would be disrupted along the snow/ice roads. The extent of this impact is unknown, but once initiated, would be difficult to control. Effects of surface layer compaction do not appear for a number of years.

Operation of a chilled gas pipeline would produce a frost bulb around the pipe which could extend several feet from the pipe, up, down, and laterally and could also increase the height of permafrost above the pipe. The influence of this frost bulb on groundwater would depend upon the temperature of the pipeline, soil type and moisture content, and temperature of the adjacent permafrost if present. The frost bulb would dam subsurface movement of ground water. Subsurface water flows would be concentrated and ponded on the upslope side of the frost bulb which would accelerate thawing of the adjacent permafrost. In areas where permafrost is not present this frost bulb would block off natural movement of water causing it to go over, under, or along the pipeline ditch.

The impact of the frost bulb on subsurface water movement would be significant in that complete blockage is possible. This would have important long-range secondary impacts on vegetation and pipeline safety.

The frost bulb formation in fine-grained saturated silty soil might induce formation of ground ice. The impact of the formation of ground ice could be a serious threat to pipeline safety as frost heaving of the pipe might take place.

In the event repair of the proposed pipeline is required during the summertime using conventional heavy equipment, there would be immediate, significant impact on subsurface water drainage. Movement of equipment and supplies across a thawed tundra surface would cause compaction and concentration of water almost instantaneously.

Wintertime repairs would cause similar impacts to those described for construction.

In many areas of the Arctic Slope of Alaska the only flowing water in the winter is in portions of some of the larger streams such as the Sagavanirktok and Colville Rivers and from springs. Spring flow areas are extremely important to overwinter populations of fish. If water is taken from these spring areas for camps, for icing snow pads and winter roads, or firefighting water, a secondary effect would be to reduce or eliminate the fish population.

Gravina LNG Site--Construction and site preparation operations such as clearing surface vegetation and grading the site would result in increased erosion and potential leaching problems. The magnitude of this impact is potentially increased because of the large amount of precipitation that falls in the Prince William Sound area. Erosion would increase the turbidity and sedimentation of Harris Creek and local estuarine areas. Construction-related petroleum products spills may also impact freshwater and marine biota by the introduction of these products into local watercourses via runoff.

Offshore construction of the proposed marine terminal would further result in temporary increases in turbidity.

The magnitude of impacts associated with the construction and existence of a proposed 600-foot long access road/breakwater and the proposed LNG terminal's wastewater discharge is dependent on local nearshore circulation. Because baseline information on nearshore circulation is insufficient, these impacts cannot be accurately assessed. However, the breakwater would affect local circulation patterns, and if circulation patterns in Orca Bay are such that waste discharges are concentrated, adverse effects to the waters of the bay would result. Expected characteristics of the operational waste discharge are presented in Table 8.2.1-47.

Spills of toxic substances such as acrolein or hydrogen chloride during plant operation could result in degradation of water quality.

A tanker collision or grounding in the area of the plant site could release Bunker "C" fuel oil carried on the tanker. The adverse effects would depend on spill size, spill location, and existing meteorologic and oceanographic conditions.

Some fine sediment which would be entrained due to construction activities in the Lowe River Basin may reach the Valdez Arm. Its impact there should not be significant.

In Prince William Sound, sediment produced by the construction activities would reach marine waters in Port Gravina and Orca Bay. The effect in Port Gravina would be locally significant at river deltas whose basins are crossed by the proposed pipeline route. This local impact should be short-term, during and for 1 to 3 months after construction if proper erosion-reduction measures including revegetation are successful. In Orca Bay, overland drainage through Harris Creek would have a significant local impact due to clearing, stripping and other construction activities at the proposed LNG terminal site. Some sediment would be carried by Harris Creek from the pipeline construction in its basin. There would be an increase in erosional processes because of unprotected ground surfaces and the large amount of precipitation that falls in the area. This would increase the silt content of streams and estuarine areas to the detriment of freshwater and marine organisms.

Vegetation--Impacts on vegetation will vary in the extent of area affected, in severity and duration and will occur from the earliest project actions throughout the life of the project and well beyond the time after the project has been abandoned. The gas pipeline project can be characterized as having five general phases of activity as follows:

1) Pre-construction
2) Construction
3) Past construction clean up and rehabilitation
4) Operation and maintenance
5) Abandonment

Emergency and repair activities can be expected to occur anytime during the first four phases.

Impact assessment becomes more difficult and more obscure with time. In other words, many of the immediate impacts on vegetation caused by site preparation, excavation and pipe laying and back filling, and the construction of permanent pipeline system support facilities are readily apparent. However, what happens to vegetation after the pipeline has been operational for its anticipated 25-year life and then is abandoned? What will happen to the permafrost regime and vegetation after the chilled gas is no longer passing through the pipeline? What happens to the permafrost and the active layer which supports the vegetative mat if the pipe is salvaged?

Pre-Construction and Construction--Initially the entire 150-foot width of the 810-mile long pipeline right-of-way would be required for pre-

Table 8.2.1-47 Waste discharge from holding pond to Orca Bay during operation of LNG plant

Flow	GPM	MGD
Average 1/	1170	1.68
Normal 1/	738	1.06
Design 1/	8867	12.77

Component	PPMW 2/	LBS/DAY 2/
BOD_5	0.4	5.62
Phosphate ($PO_4^{=}$)	1.5	21.08
Chloride (Cl^-)	12	168.60
Oil	<1	14.05
Suspended Solids	5	70.25
Total Dissolved Solids	52	730.60

Temperature of discharge would be 61°F and pH would be 7.0

1/ Major portion of flow in storm water run-ff from process units and LNG tank farm areas.

2/ Values given are for average conditions.

Source: Federal Power Commission, 1975, Vol. II

construction and construction activities--a total of 14,712 acres. An additional 1,475 acres would be temporarily utilized for construction of compressor stations, maintenance facilities, and the LNG facility. All brush and trees encountered along the pipeline right-of-way would be hand cleared. The work and spoil pads would then be constructed by pushing snow from along the right-of-way into piles next to the pipeline ditch. The applicant has stated that in the event of an early snowfall the snow along the right-of-way would be cleared using rubber-tired, low-ground pressure vehicles, with snowplow attachments, to accelerate freezing of the active layer. Where the terrain must be leveled by ripping and blading, the snow cover and organic surface layer would be removed and stockpiled.

The impacts caused by this portion of the right-of-way construction include the complete destruction of shrubs and trees, the disturbance and reduction in numbers of herbs and thalloid plants due to vehicular traffic and blading of snow, and an increase in the active layer due to reduced albedo and compaction of the organic surface layer resulting in reduced insulation. The amount of increase in the active layer is dependent on the vegetation type disturbed, the type of soil involved, the time of year and the intensity of disturbance. The change in the thermal balance caused by the removal or reduction of vegetative cover would result in thermokarst subsidence, slumping, rutting and other types of permafrost degradation. Once initiated these processes are long lasting and difficult to control.

Project plans are to dispose of slash from the hand clearing of trees and shrubs by mulching. The proposed advantages of this method are that it minimizes the potential for outbreaks of insects such as bark beetles, it reduces the possibility of wildfire, it restores nutrients to the forest floor, and possibly provides some insulation.

Approximately one third (53.5 feet) of the 150-foot width of the 810-mile long pipeline right-of-way would be required for construction and operation of the pipeline. This represents approximately 5,247 acres of existing vegetative cover that would be permanently destroyed.

Because the majority of the pipeline ditch excavation, pipe installation and back filling would be done in the winter, the active layer as well as the permafrost would be frozen solid. The so-called "super ditchers" would only be used in special situations due to their uneconomical operation. Ditching would be accomplished by a combination of blasting and excavating with backhoes. It is estimated that approximately 77% of the route would require blasting.

Excavation of the pipeline ditch would destroy the insulating mat of living and dead vegetative material along the 810 miles of pipeline route from Prudhoe Bay south along the route to Prince William Sound. The ditch would transect an uncounted number of plant communities and result in the loss of individual mosses, lichens, sedges, grasses, herbs, shrubs, and trees from at least the area excavated, and probably cause a loss of much of the plant cover over the adjacent right-of-way area where plants will be broken and mashed by machinery or covered by excavated dirt.

Ditching and backfilling would leave the pipeline mound devoid of living plant cover, but it is assumed that the tundra vegetation would be removed from the pipeline prior to ditch excavation and replaced on the ditch berm after the pipe is placed and the ditch is backfilled. This may be impossible along the route where construction would take place in midwinter while the ground is frozen. Under these conditions, the organic mat would probably break up into pieces which are not large enough to survive during ditching, stacking, and subsequent replacement.

In addition to the 5247 acres of vegetative cover destroyed by the 53.5 foot-wide operational portion of the pipeline right-of-way, the permanent land requirements of other facilities associated with the pipeline system would result in a total of 955 acres of existing vegetative cover being permanently destroyed. These facilities include the construction of permanent roads, airfields, compressor stations, helicopter pads, communication sites, maintenance camps, meter stations and spoil disposal from tunnels. The permanent land requirements for the LNG site at Pt. Gravina and its auxiliary facilities, 450 acres, are included.

Since virtually all of these areas would be overlain with gravel and would be in use during the operation phases of the project, there will be little chance of restoring plant production on them. The loss is, therefore, irreversible. The loss of net annual primary production from those acres, while locally significant, would be slight in relation to that available. It would amplify the loss associated with the construction of the oil pipeline.

One aspect of the preconstruction and construction phase that merits special attention is the plan to utilize snow and ice surfaced winter roads. We are especially concerned about the snow collection or gathering aspect of the plan which will involve scraping snow from large areas adjacent to the pipeline. The impacts of this could be particularly significant during periods of low snowfall and especially so in the north slope area where snowfall is normally very limited in amount. Even the most skillful and conscientious equipment operator will inadvertently gouge and scrape the vegetative mat due to the uneven ground surface, poor visibility during darkness and harsh winter weather and due to sparse snow cover in some areas.

This could have two impacts. One could be major and difficult to mitigate--the permafrost region could be adversely affected by the removal of the vegetative mat which would allow a deeper thaw of the active layer and possible subsidence due to additional melting of the underlying permafrost in ice rich sections. The other impact would be significant but should be possible to mitigate--the vegetative mat itself would be directly degraded by physical removal during snow gathering operations and indirectly degraded by the subsequent subsidence of the ground due to the additional thawing of the active layer and ice rich sections of underlying permafrost.

Snow collection and general construction clearing within river flood plains might result in damage, or destruction of riparian willow shrubs. Willows sprout readily, so such damage would have little long-term effect on the riparian communities, but a short-term loss of such shrubs could have a severe local adverse impact on moose confined to those river valleys during the winter (see Wildlife).

In addition to the direct loss of vegetation from the 6,202 acres permanently changed by construction (5247 acres-pipeline and 955 acres-LNG site and pipeline system support facilities) an indeterminate but significant acreage of vegetation would be affected by secondary impacts through changes in various physical conditions of the plants' environment during all phases of project activity. These secondary impacts which modify habitats could result in greater long-term changes in plant communities and the functioning of the various ecosystems than the seemingly more severe short-term construction impacts. Although mitigation of some of these secondary impacts through revegetation and other means will probably be successful the total result of mitigation is unknown. It is quite possible that there will be some kind of a net change in vegetation types and composition and numbers of plant communities from the original pre-project vegetative condition.

Post Construction Rehabilitation--Removal of the insulating plant cover and trees would expose bare soil along the pipeline route which would induce local changes in the microclimate and initiate a series of impacts on the soil leading to various forms of soil instability, erosion and water quality deterioration discussed in the sections on soils, water, and erosion hazards. Stabilization of bare soil surfaces would be necessary to prevent a further loss of vegetation on unstable sites, and in some cases mechanical stabilization measures (or structures) might be required before revegetation of the disturbed sites can be effected.

Restoration of a plant cover to all disturbed areas is important for one or more of the following reasons:

1) control soil erosion;

2) restore natural thermal energy budget of soil and prevent permafrost degradation;

3) diminish the esthetic impact of a 810-mile long scar; and

4) restore a measure of primary production to the disturbed tundra ecosystem.

The pipeline right-of-way would need to be vegetated with a mixture of grasses the first spring after construction. Seeding and growing of grasses on disturbed sites particularly in the Arctic are now in an experimental stage and little experience is available from which to predict proper methods or their likelihood of success.

The scanty evidence to date indicates that certain exotic varieties of agronomic grasses can be expected to germinate and grow more successfully than the native grasses, at least during the first few years. The native grasses would gradually dominate the site as the percent of plant cover increases but plant succession proceeds very slowly and it may be 30 to 50 years before the vegetation on the pipeline mound resembles that in the adjacent undisturbed communities. Therefore, the pipeline would be a discordant element in the vegetation for many years and will show up as a long, straight line with color and texture different from the surrounding landscape (see esthetics). Trees and brush would be allowed to re-establish in the 150-foot wide right-of-way outside of the permanent central 53.5-foot wide operational part of the pipeline. Thus that portion of the right-of-way outside of the central permanent strip would be allowed to regrow and follow natural successional stages. To ensure good visibility of the pipeline route during aerial patrol for leak detection, and to permit access to repair and maintenance crews, any shrub growth along the permanent right-of-way would be eliminated. In addition, the vegetation controlled areas along the pipeline and around compressor stations would provide a buffer zone for protection against wildfires which are common in the interior of Alaska. Herbicides may be used during the life of the project if no other suitable alternatives are found for shrub control. The removal of shrubs would prevent normal succession and maintain the vegetation at a lower successional stage.

Applications of grass seed and fertilizer at various spots along the pipeline would probably be necessary each year as the backfilled ditch slumps, settles, consolidates, erodes, and eventually stabilizes. Fertilizers applied as an aid in revegetating disturbed terrestrial areas might become pollutants if introduced in sufficient quantities into water courses.

Operation of Pipeline--The pipeline presence and operation would have an indirect, but long-term effect on all the vegetation. Site changes would include changes in soil moisture, surface drainage, soil temperature, nutrient availability, microrelief and the depth of the active thaw layer. The cold buried pipeline and the mound of dirt over it would, at various places, impound, impede, and divert the normal flow of surface and subsurface water despite the use of granular fills and cross drains (ditch crossings) to allow its passage (see Water).

Wetland communities which are deprived of their normal water supply by the diverting influence of the pipeline would gradually be replaced as plant species better adapted to drier sites become established.

Lower soil moisture in the pipeline berm, reduced soil temperatures over the chilled pipe, and increased microrelief would create another set of conditions alien to the present plant communities and would probably result in at least two new sets of communities growing along the crest and side slope of the pipeline mound. These various changes in plant species would radically modify the landscape through which the pipe passes, and make its location easily visible to the knowledgeable observer.

Spills of petroleum products and other chemicals pose potential impacts during operation of the pipeline; their effect would be local but of unknown significance with respect to both terrestrial and aquatic vegetation.

There has been little work done on the long-term impact of air pollutants on the arctic and subarctic environments of Alaska. One problem that appears likely to occur and might already have started due to the extensive gas and oil gathering facilities is that of degradation of lichen by emissions of sulfur dioxide (SO_2).

It would appear from first glance that the .5 ppm peak emission rate from a compressor station is small and well within the standard for Alaska, the unusual nature of the Alaskan environment and the extreme sensitivity of lichen to sulfur dioxide would cause large-scale reduction in lichen communities during the operation of this proposed pipeline. Loss of lichen would have a detrimental impact on caribou populations since lichen is their primary winter food. Impacts on caribou populations would in turn affect any Alaskan natives who still depend on the caribou for sustenance.

Long exposures to .05 ppm of sulfur dioxide are considered damaging to fruitcose Cladonia lichen (Schofield and Hamilton, 1970) which is one of the most abundant lichen types in Alaska. It is known that lichen absorb moisture and elements from the air. The elements are accumulated in the lichen so that even small concentrations of pollutants would, over a long period, become concentrated in the cells. When exposed to SO_2 the lichen first absorb and then oxidize it into sulfuric acid. This chemical directly inhibits photosynthesis. As the concentration increases with time, the plant is unable to produce enough food and slowly dies. This process is enhanced by the presence of fog and icefog. The sulfur dioxide is scavenged by the water and ice droplets and directly deposited on the lichen and absorbed. This was proven experimentally by Rao and LeBlanc (1966) who found that the amount of sulfate in lichens increased with increased humidity. The possibility of dangerous concentrations occurring due to emissions from compressor stations, gas gathering facilities and other facilities exists in Alaska due to the high incidence of fogs, calms and inversions which would concentrate SO_2 emissions and thus damage lichen communities.

The huge volume of hot water vapor emitted from each compressor station would also have a definite but unknown effect on plants. Plants growing in a moisture-deficient area will react quite differently from those plants on a moist site. No information is available to assess these impacts.

Emergencies might require pipeline repairs during the summer when the ground is not completely frozen. During this period when the root zone is thawed, all plant communities are most susceptible to disturbance, and repair and maintenance activities at that time have the greatest potential for adverse impacts on vegetation.

Pipe, repair equipment and other materials would be stockpiled at compressor sites. Equipment would then be moved along the route where necessary by low ground-pressure vehicles or by air-crushed vehicles if developed and if available. In general, the wetter the plant community the more damage it would sustain.

The resultant effect is usually a depression where the vehicle tracks run and the depressions range from slight in winter to several inches or more in the summer. On a slope these depressions can start water collection and erosion, or if permafrost is present, thermal melting and thaw consolidation of soil. Impacts to vegetation from tracked vehicles can be severe where plant roots are eventually eroded away and/or permafrost is melted.

Wildfires would occur during all phases of the project.

The gas pipeline route crosses tundra and a variety of forest types. In doing so, it would encounter various vegetative types and plant communities that have certain wildfire characteristics. The likelihood of fire resulting from activities related to the construction, operation, or maintenance of this gas pipeline or, conversely, the likely occurrence of a fire threatening the integrity of the pipeline, can be evaluated from information on: (1) distribution and flammability of plant communities along the proposed route; (2) location and timing of pipeline-related activities with potential for starting a fire; and (3) annual climatic variation as it affects the spread of fires.

Although all vegetation zones crossed by the proposed pipeline route are subject to fire, they differ in their ability to carry a fire, once it has begun as follows:

Vegetative Type	Rate of Spread	Resistance to Control
Coastal Hemlock-Spruce	Low	Low
Upland Spruce and Hardwood	High	Medium
Lowland Spruce and Hardwood	High	High
High Brush	Low	High
Low Brush	Medium	High
Moist tundra	Medium	Medium
Bottomland Spruce and Poplar	Medium	High
Alpine Tundra	High	Low

Lightning fire occurs infrequently north of latitude 68°30', consequently most of the major fires would occur in the interior Alaska portion of the route.

The potential for wild fire would be increased because of pipeline-related causes. These include: (1) equipment- exhaust and ignition, vehicular and aircraft accidents, (2) recreation- warming and cooking fires, sightseeing parties, (3) smoking- discarded materials, (4) industrial- heat sources present during construction and maintenance, welding and cutting torches, debris burning, (5) structural, gas, and petroleum fires, and (6) miscellaneous- signal fires, fires by arson.

With the introduction of additional ignition sources on the gas pipeline route there would be an increase in numbers of fires with a resultant increase in affected acreage.

All man-caused fires which occur would be suppressed, since they would be a threat to man and his improvements. During construction phases, the number of man-caused fires would be great, detection early, and acreage burned small. During the operational-maintenance phase, the number of fires would be fewer, detection later, and acreage burned would be greater.

It is impossible to predict the number of man-caused fires and acreage burned that would result from the project. The number of fires would be higher because of man's increased presence. The severity and incidence of fires would be influenced by the following factors: (1) The length of the fire season (period of time when burning conditions will sustain fire), (2) The degree of susceptibility of fuel types to ignition and the rate of spread of the fire, and (3) The degree that weather factors in the Interior favor conditions causing more fires.

With the exception of those fires that directly threaten humans and pipeline facilities, the effect on the environment could be beneficial. Wildfires in the taiga and tundra of interior Alaska are, and probably always have been, integral dynamic processes of ecosystem functioning.

Fire acts as a by-pass of the decomposition process, which is limited in the Interior by dry and cool conditions that inhibit microbial activity and as an important agent for recycling essential nutrients that otherwise become tied up in dead organic materials, such as litter, standing dead plants, and peat accumulations. It also acts as a natural disruptive force that prevents succession of vegetative communities to a climax type, with its improverished diversity in structure and species numbers.

Thus fire is essential to ecotone, or "habitat edge," development which enhances both primary and secondary (i.e., wildlife) productivity.

On the other hand, fire suppression actions would tend to offset the beneficial aspects of fire. It is typical of fire fighters to be so intent on their fire suppression activities that the environment is often more seriously degraded than is necessary. The damage caused by bulldozers used to clear fire breaks and that of vehicles used to transport men and equipment across the tundra or taiga would have severe and long lasting effects on top layers of soil, the vegetative mat and on the integrity of the permafrost regime. Soil erosion involving severe and long lasting gullying would be one effect. Another would be subsidence of the surface due to the degradation of the underlying permafrost. Examples are increased stream turbidity for several years after a fire, gullies 20 to 30 feet deep in just two years following the bulldozing of fire guards and fire breaks and continual periodic slumping of the ground surface. The impact of fire suppression activities on the environment will often have a greater net long range degradation effect than the net destructive effect of the fire itself. Thus, the effects of fire suppression is considered to be one of the major and most adverse of all impacts associated with the gas pipeline project.

Abandonment--At some point in time (probably 25 to 50 years after start-up) the pipeline will cease to be used to transport natural gas. This would be due to the depletion of gas at the Prudhoe field or due to the depreciation of the pipe beyond safe structural limits.

Leaving the inoperative pipe in place would probably have little effect on the environment. However, salvaging the pipe would severely disrupt the ground and could cause long lasting permafrost degradation with its associated gullying and other severe erosive processes.

Wildlife--The construction of this pipeline system would affect wildlife populations through: (1) direct and indirect harassment or project-caused disturbance during critical periods of animal life cycles; (2) increased harassment and/or destruction of wildlife because of better access to area; (3) the introduction of pollutants to the ecosystem; (4) the inability of certain species of wildlife to adapt to man's presence; and (5) the direct or indirect destruction of wildlife habitats. Because this alternative route would closely parallel the Alyeska oil pipeline, certain impacts e.g., noise and pollutants from gas compressor sites added to noise and pollutants from oil pump stations, would be cumulative.

Fish and Other Aquatic Life--The overwintering areas for fish in Alaska are limited to those streams and lakes which are deep enough to prevent the ice from freezing solid. These pockets of water are naturally low in dissolved oxygen due to limited exposure to surface air. Any changes in the local environment that would lower the oxygen levels could have major detrimental impacts on the organisms found there. Increased levels of organic matter in the aquatic systems would increase the biological oxygen demand and reduce the amount of oxygen available to the fish. Domestic sewage from construction camp would be an example of an extraneous source of organic matter. Any reduction of oxygen in the over-wintering pools could reduce the numbers of fish that would be able to survive. Nutrient-laden silt eroded from areas where revegetation efforts are being carried on would also possibly increase the growth of primary producers such as plants and algae. Greater volumes of plant material will consume more oxygen when decomposition occurs and lower the amount of oxygen left for fish.

Another impact associated with the overwintering areas of fish is that of water withdrawal from these areas for ice on snow-road construction and camp water. These withdrawals could have major impacts on resident fish populations. In many cases, these pools contain concentrations of entire stream or lake populations that would be eliminated or reduced drastically by any change in the water level of the pool.

During the construction and operation of the proposed pipeline and LNG facility various chemicals would be used, such as gasoline, fuel oil, metal primers and paints. The possibility of spillage would be ever present and would constitute a threat to the local environment, especially the fish, in the event of a spill.

The proposed pipeline construction would require the placing of culverts in streams crossed by roads. These culverts can act as barriers to fish migrations. This would happen if the culvert is too narrow for the particular stream it is set in and the resultant increase in the velocity of the water as it passes through would be too strong for fish to swim against. The maximum current allowable would be related to the species of fish that must pass through, the size of the fish, and the temperature of the water. A poorly designed culvert could change spawning and migratory patterns to the detriment of area fish populations. Culverts are potentially more damaging to stream dwelling populations of fish, particularly grayling, than any other aspect of pipeline-related activity.

Mammals--

1. Caribou. The proposed route passes between the areas normally occupied by the Arctic Caribou herd (243,000 animals) and the Porcupine Caribou Herd (140,000 animals). Animals from the two herds mingle on their wintering areas south of the Brooks Range and may use some of the same passes to travel to their calving and summer ranges on the Arctic Slope. The primary calving and summer areas of these two herds are west (Arctic herd) and east (Porcupine herd) of the route.

The route also crosses the spring-fall migration route of the Nelchina Caribou herd (less than 20,000 animals). During some years, the Nelchina Basin is an important wintering area.

Caribou are characteristically migratory throughout their ranges in Alaska and their well-being depends upon these movements. Although migration routes of caribou show some variation from year to year, there is a general consistency in areas travelled and in their timing. Obstruction to their movements, which could result in substantial delays or failure of the animals to reach traditional calving or seasonal grazing areas, would also likely alter the distribution of caribou in the future and account for the abandonment of portions of their range, to the detriment of the population.

Snow fences proposed to collect snow for temporary roads could become temporary barriers to seasonal caribou movements to the calving grounds in the spring and toward the wintering areas in the fall. The pipeline berm, and road and airfield embankments, would remain as permanent features of the landscape and potential threats to free movement of caribou.

If the pipeline facilities should cause any of the three herds to abandon its calving area, the herd might not be successful in calving elsewhere, and become incapable of maintaining its present numbers.

Another primary impact of pipeline construction and operation would be the reduction of caribou habitat because of the construction of permanent roads, airfields, compressor stations, communication sites, borrow pits, and other related structures; and the impact of these facilities on caribou behavior. The actual loss of forage plants can be considered minor in relation to the range now available. The presence of roads, structures, vehicles, compressor noise, and people would cause a larger, but unknown, area temporarily unattractive and unavailable to caribou. Spilled fuel and other pollutants would have severe site-specific effects on caribou forage plants.

Summer pipeline repair and maintenance activities would increase the amount of caribou range disturbed and/or destroyed, but these impacts would be local. The extent of impact would depend on the length of line to be repaired and the amount of time taken to repair it.

The most severe primary impacts as a result of the proposed pipeline would be those affecting caribou behavior and population dynamics rather than habitat.

Winter construction activities would have a direct effect on individual caribou. The Porcupine and Arctic herds would be particularly affected. The structures built during the winter would remain to influence animal behavior at other times of the year, and indirectly, the herds' population.

Fixed-wing and helicopter aircraft would constitute a disturbance to caribou at all seasons. Caribou generally do not flee from aircraft flown above 500 feet, but they still experience fright reactions. Such disturbance could be experienced year-round especially at the airstrips and helicopter landing pads. Disturbance during the summer by low-flying aircraft would affect a great number of animals, but it is the harassment of the caribou encountered in winter that can have the worst direct impacts on individual animals. In mid-winter, when the daily energy balance of a caribou is low, harassment could cause the animal to expend more energy than it could acquire from the available forage, thus placing the animal at a net energy deficit. Repeated harassment could result in the death of that individual. In the summer, disturbance by aircraft would be most critical during the calving period.

Another adverse effect includes increased access to a herd leading to increased hunting. There is no reason to expect that the improved access to areas associated with the proposed pipeline would produce other effects.

2. Moose. This species is not abundant north of the Brooks Range. They concentrate in the riparian brush areas along stream bottoms during the winter and spread out over much of the Arctic Slope whenever they can find browse during the summer.

Moose are more numerous though not abundant in the Yukon River Basin. Here, also, they concentrate in willow covered stream bottoms during the winter and spread out on the countryside in the summer.

In the Copper River Basin, moose are abundant but south of Thompson Pass, they are scarce because of the lack of suitable habitats.

During the winter moose concentrate in willow thickets along the major streams where they browse the buds and twigs of willow. Each borrow pit, road, pipeline, or other facility which crosses a stream or encroaches on the riparian willow thickets would reduce the winter food available to moose. Since natural winter range is already in short supply and the natural supplies have been further reduced by oil pipeline material sites, any further reduction would have a cumulative adverse impact on the moose population. If snow is collected to construct temporary roads from these streamside willow thickets, the damage done to the shrubs would also have an adverse impact on winter food for the moose.

Winter construction activities may also disturb the moose gathered in the river valleys enough to displace them from the area. On an already limited range, this disturbance and displacement may adversely affect the individual's energy balance and subsequently may result in death.

While not considered migratory in the same sense as caribou, moose do undertake seasonal movements. Any obstruction of these seasonal movements as a result of pipeline construction and operation would reduce the efficient utilization of their habitat and could isolate essential components of their range which may result in a reduction of animal numbers.

3. Dall Sheep and Mountain Goats. Dall sheep in the Brooks Range tend to concentrate in winter and spring on south-facing slopes in areas of reduced snow accumulation. Two such areas are immediately adjacent to this proposed system. They are the north side of Atigun Canyon and at the head of Dietrich River near the Chanadalar Shelf. Lambing also takes place in those areas. Mineral licks, used by the sheep in spring and early summer, are also located very near the proposed pipeline right-of-way. Mountain sheep populations utilizing these areas would experience considerable stress even under the best of construction and pipeline operation conditions. Past

pipeline activities associated with Alyeska construction would already have had an adverse effect on these animals.

The Isabel Pass area in the Alaska Range is also known for its population of Dall sheep. The Wrangell and Chugach Mountains support good populations of sheep, with mountain goats replacing sheep from Thompson Pass south.

Sheep and goats in these areas would not be closely associated with pipeline construction activities. Nevertheless, a most serious and direct effect of pipeline activities would come from aircraft flights associated with construction and maintenance activities.

Sheep are usually frightened by aircraft. The noise is probably the main reason (Price, 1972), but the sight of the airplane may also play a role. Such disturbances disrupt normal behavior patterns and generate physiological stress. The significance of disruption of behavior patterns on the well-being of Dall sheep has not been fully evaluated, but it is known that disturbance immediately following birth may result in a substantial decrease in survival of the newborn young (Pirzman, 1970).

The reaction of goats to aircraft is largely unknown but is thought to be similar to that of sheep.

4. Buffalo and Musk Oxen. Two small herds of buffalo inhabit areas adjacent to this pipeline route. One herd (200+ animals) is centered near Big Delta and the other (150+ animals) in the Copper River Basin near Copper Center.

The primary impact of proposed construction and operation of the pipeline would be disturbance of these animals during critical periods of the year. Harassment by ground vehicles or aircraft, especially during calving or wintering periods would be harmful to the herds well-being.

Most of these herds' range is far enough removed from the line so that actual reduction of food sources should be no problem. Attempts to re-establish musk oxen populations have included introductions in various locations throughout the state. One such population occurs 35 to 40 miles from the pipeline route. While construction is not expected to affect this herd its location should be avoided by any and all aspects of the construction proposal.

5. Deer. A small population of Sitka black-tailed deer inhabit the forested areas in Prince William Sound from the timberline in the summer to the beach areas in winter.

Construction of the pipeline to Gravina Point and the larger development there for liquifying and shipping the natural gas reduce habitat for these deer and make them more vulnerable to hunting through increased access.

6. Wolves. Wolves are present throughout the area of this proposed transmission system. Numbers depend on availability of prey species, time of year and presence of suitable denning areas. Construction and operation of the proposed pipeline would have adverse primary and secondary impacts on the wolf population and its habitat.

The primary impact of construction activities would be the loss of choice den sites found in areas which are chosen as upland borrow sites for road and airfield and other materials. This impact could be significant in combination with the areas in the region already destroyed or otherwise made unusable by the construction of the Alyeska oil pipeline in the pipeline corridor.

Wolf dens are often used year after year because of the difficulties of digging in permafrost soils. Any construction or pipeline operation activity within sight, or hearing, of these established dens could cause their residents to abandon the den as long as the human presence persists.

The presence of a large number of humans, particularly where very few have ventured in the past have direct effects on populations of wilderness species such as wolves, grizzly bear, and wolverine. Wolves are vulnerable to hazing by airplanes and snowmobiles and increased hunting, and some individuals may be attracted to edible refuse and ultimately become somewhat dependent on such food sources.

Increased access to the area, and increased human presence would likely intensify hunting pressure and also increase the likelihood of illegal killing of wolves by those seeking such a trophy. Since wolves do not generally migrate out of an area, or hibernate during the winter they are exposed to harassment and hunting year around and would probably suffer their greatest losses during the winter seasons when the pipeline and ancillary facilities are to be built.

7. Furbearers. Among the furbearers along the proposed pipeline route are arctic and red fox, wolverine, martin, lynx, weasel, beaver, river otter, muskrat, and mink.

Impacts of construction and operation of the alternative pipeline would be to (1) reduce habitat by physically changing it, e.g., destroying denning areas or polluting waterways or feeding areas necessary for survival and (2) increase accessibility and making these animals more vulnerable to hunters and trappers.

8. Bears. Polar bears inhabit only that portion of the Arctic Slope nearest the Beaufort Sea. Because of earlier development activities, polar bears may no longer use the area associated with this gas transmission system on a regular basis.

Grizzly bears inhabit the entire area of the proposed pipeline. Activities associated with construction of the Alyeska oil pipeline would undoubtedly have reduced numbers to be affected because most grizzlies do not survive in the presence of development. Some grizzly, however, do become attracted to camp and dump sites.

Black bear are present in the area south of the Brooks Range. The greatest numbers are located in the heavily forested areas in the Fairbanks area and the Copper River Drainage.

Being more tolerant of human activities than grizzly bear, they tend to make more of a nuisance of themselves. Because of this and a certain trophy value, the construction and operation of this proposed pipeline could have an adverse effect on their numbers.

9. Small Mammals. Throughout the area that would be affected by this route are a large variety of small mammals including shrews, voles, squirrels, hares, lemmings, marmots, pikas, etc. Construction of the gas transmission system would result in a local reduction of habitat for these small mammals, thereby reducing their numbers. This could have the secondary effect of reducing the population of larger predators dependent on the species. The loss of habitat and population reduction would have different implications for each of the small mammal species, but this can be considered insignificant in relation to the amount of such habitat and numbers of small mammals along the corridor. Even the loss of this food source is likely to have less effect on the carnivores than would the presence of human activities in their territories.

Birds--Approximately 352 species of birds can be found at some time of year in Alaska. Because of the wide range of habitats that the construction and operation of this gas transmission system would pass through, a large percentage of these species would be affected.

Potential conflicts between the proposed construction and bird populations can occur from disturbance, habitat destruction, pollution, and direct mortality. Some of these impacts are unavoidable. Many can be avoided, depending on the location of various facilities, construction practices, and scheduling of activities. Among the major potential impacts which could be avoided are those caused by aircraft and human presence at certain critical times.

The construction phase of this proposed gas pipeline system would not directly affect bird populations in general, but it would contribute to attrition of birds through exploitation and deprivation of habitat. This would be in addition to the habitat lost through construction of the Alyeska oil pipeline.

Oil and other pollutant spills occurring on land or water because of construction or maintenance procedures are detrimental to birds and their habitat. This threat cannot be evaluated, because the effect of spills would be related to the location and volume, and to the season of the year. Migratory birds that are adaptively restricted to coastal habitat are especially vulnerable to pollutants entering the Beaufort Sea from either the construction or operation of this pipeline system.

The proposed pipeline traverses several major and many minor drainages flowing into internationally important waterfowl production areas. Pollutants unintentionally discharged in and remaining within the drainages of the Sagavanirktok, Koyukuk, Yukon, Tanana, and Copper River could damage habitat and kill waterbirds unique to these areas. The occurrence of such events cannot be predicted nor the results evaluated because of the uncertainties involved. (USDOI, 1972).

One aspect of spilled and pooled oil affects birds specifically; birds are attracted to pools on the ground, shore or ice. Oil sumps are known to take a toll of ducks, shorebirds, songbirds and even raptors (King, 1953; Bloch, 1964). Waters that are polluted may be the first to become ice-free in the spring, because of the "black body effect," and attract early migrants.

Disturbance would probably drive away, at least temporarily, all birds from the sites of construction activity and some birds from adjacent areas. Although the tolerance of birds to disturbance varies with species, season, stage of nesting and type of disturbance it has never been quantified. Observations suggest, however, that geese, swans, loons, cranes, and raptors are generally less tolerant of disturbance than most small passerines, shorebirds, and some ducks. (USDOI, 1972).

Some species may adapt to new and increased disturbance, whereas the detrimental effects of increased disturbance could be cumulative on other more sensitive species, such as nesting whistling swans or raptors. The area of disturbance in this case would have already been disturbed by the construction and operation of the Alyeska oil pipeline.

Disturbance could increase stress and alter normal behavior patterns during critical life history phases such as spring migration, nesting, molting, or fall migration staging; decrease reproductive success; or cause the birds to desert areas such as traditional molting or nesting sites for which there may be no alternative. The impact of disturbance on a particular species is a function of the type and intensity of the disturbance, the time of year, the location, the mobility of the disturbance source, the distribution pattern of the bird, and the species' sensitivity to disturbance. The major sources of disturbances associated with construction and operation of the proposed pipeline are aircraft traffic, construction activities and human presence, permanent facilities and water traffic.

Unique Ecosystems--Several "unique area" studies have been conducted during recent years to identify and suggest protection of areas in Alaska which are physically and/or biologically in as nearly an undisturbed condition as possible.

From studies conducted by the University of Alaska and several Federal agencies, the Joint Federal-State Land Use Planning Commission for Alaska recommended in 1973 that: a systematic statewide analysis of nominated Science Research and Natural Areas be undertaken to develop a balanced and representative statewide system of such areas.

Included among nine near the proposed route which were nominated is the Franklin Bluffs site.

The Franklin Bluffs site (size not specified) is located on the Sagavanirktok River. These bluffs are a prime nesting area for the endangered peregrine falcon (see wildlife, birds, section for discussion of falcon in this area). Studies have been conducted in this area on falcons and fish by the State Department of Fish and Game, University of Alaska, and U.S. Fish and Wildlife Service. Much of the natural undisturbed bluff area is just above where the pipeline would pass through a narrow valley. The oil pipeline road and pipeline which is under construction pass just along the west side of this canyon.

To serve its original purpose as a natural study area this site would have to remain relatively undisturbed.

This site has been somewhat disturbed by the oil pipeline activities and would be subjected to additional disturbance by aircraft along with spring and summer operations and maintenance activities.

Endangered Species--The endangered peregrine falcon utilized the Franklin Bluffs Area as a prime nesting location (see "Unique Ecosystems" above). This is within the zone of possible disturbance by the pipeline construction.

Winter construction activities would not directly affect these birds, but they would be adversely affected by disturbance from aircraft, or human presence, while nesting and raising their young. Thus, spring and summer operations and maintenance activities are most likely to affect the peregrine falcon by temporarily or permanently lowering its population.

Ecological Considerations--Since the project is not readily comparable with any other undertaking, the impacts discussed are largely conjectural. In general, it is believed that with the possible exception of endangered species, impacts will be nominal by virtue of their being of low intensity or brief in duration.

It should be noted that several of the discussions on wildlife impacts dwell on possible effects on interspecific relationships, animal behavior, energy reserves, successional patterns, etc. These are subtle factors which are not readily measured and their ultimate impacts are not easily demonstrated. They are clearly in contrast with the tangible measureable factors which are usually sought for decision making. Yet, these subtle factors often account for long-term erosion of populations or ecosystems. Through these ecologic processes, Alaskan ecosystems could be severely impacted by the collective effects of this project and future developments which will almost certainly be realized.

Economic--The construction of this proposed alternative and the eventual flow of gas through it would have both a direct and indirect impact on State revenues. Indirect revenues gained by the State would be primarily through personal income taxes and certain excise taxes. The major revenue impact of the gas pipeline would be direct, based on increased gas production tax revenues, royalty payments to the State (after gas begins to flow), and on State property taxation of the pipeline itself.

Indirect revenues, with the exception of corporate income taxes of the company that owns the pipeline, subside with the completion of the construction phase of the project. As these revenues diminish, however, the gas production and pipeline's direct revenue impact would begin.

Prediction of the level of revenues from the direct sources is difficult. There is uncertainty about the amount of gas available and final costs of production are uncertain. The future well-head value of gas is unknown, but large amounts of revenue seem assured to the State and the developer and shipper from this source.

The State property tax rate applicable to the Alyeska oil pipeline and facilities is currently 20 mills. The state has estimated that Alyeska will generate about $56 million in pipeline property tax revenue at the peak year. Tax revenues generated by this alternative would be on the same order of magnitude.

A serious economic impact of this project will relate to the recession that must be faced by the majority of communities lying along the route after construction is completed. This is an important consideration in a state with a very small population base. Alaska is well acquainted with boom and bust economics. The Alyeska Pipeline project is such an event of massive proportions. The proposed natural gas pipeline project will precipitate still another cycle or, with fortuitous timing, it may extend the current boom. Either will be followed by bust.

The character of Alaska's population has been markedly changed in the last few years. One of the changes which will have the biggest economic impact in the future is the shift in approach to heavy construction. Construction has traditionally been oriented to the summer season permitting the major part of the work force to maintain homes outside of Alaska. The switch to year-around construction is certain to find more and more of the members of the transient work force shifting their residences to Alaska. Another trend that can be noted is a tendency for established residents to move from service jobs to better paying construction jobs. They are being replaced by new residents. All of this adds up to an increased population with a wider economic base. Table 8.2.1-11 shows the trends in population and employment from 1961-1973. The trends mentioned above are not yet apparent in the published data. This alternative would magnify the change already occurring.

Table 8.2.1-12 shows the sources of industrial income in 1970. It is obvious from the data that lumbering and fishing no longer occupy the dominant places in Alaska's economy that they once did. They would become relatively even less dominant if this gas transportation system became a reality.

Due to the variables of location and probable on-site services for the persons filling industrial jobs, estimates of disposable income to be spent within the state are highly subjective. Persons filling jobs resulting from secondary employment, while likely to earn a lower income, would spend a substantially greater percentage of gross income within the State because they would be primarily in supporting communities and not supplied with room, board, and other necessities by employers as would construction workers.

Note that these estimates relate to the estimated disposable income expenditures in Alaska by employed persons. Taxable income totals would be substantially higher. Disposal expenditures outside of Alaska would also be substantial (conservatively estimated at $22 million over the four calendar years 1976-1979, inclusive).

This gas transmission system would have approximately 800 miles of pipeline in Alaska, 12 compressor stations (AAGPC), and a multi-billion dollar LNG plant and tanker fleet.

Disposable income expenditures from construction of the system would be several orders of magnitude larger than the AAGPC proposal.

Construction of this system would have a multi-faceted impact on the socio-economic environment of the State of Alaska in general and the Prince William Sound region in particular. It would produce jobs, generate State and local revenues, and further stimulate the Alaskan economy. It would attract migrants to the State, creating demand for social services, schools, housing, health care, and public safety.

Construction of the project would represent an incremental influence on government manpower requirements. State government employment is expected to further enlarge during the gas pipeline project. The increased importance of the State government sector reflects an existing trend of diminishing Federal involvement in Alaska, the unique needs of the State, and a necessary expansion of State services. Local government employment is expected to increase during the gas pipeline construction phase. Municipal governments in Fairbanks, Valdez, and Cordova would expand the number of police, fire, sanitation, road maintenance, and administrative personnel to reflect the expansion of their economies and demands made upon these services by construction workers and their dependents.

Gas pipeline construction might have a direct adverse impact on the fishing industry especially in the Prince William Sound area and minimal impact on the forest industry, which would continue to be dependent upon world markets. Mining could be expected to grow somewhat because of the increase of access to mineral rich areas. The manufacturing sector of the economy could be expected to grow, specifically because of the LNG plant. Other increases would likely be limited to the manufacture of petroleum industry-related products for (and from) oil and gas exploration activities. Agriculture would continue to diminish in importance in relation to the entire economy, but tourism could be expected to grow throughout the period of gas pipeline construction, unless it is slowed by the national energy shortage.

Pipeline construction would create a demand for transportation services. The construction effort would utilize the barging, trucking, and aircraft resources of the state. Barging impact should be primarily confined to Anchorage, Valdez, and perhaps Cordova while Fairbanks would serve as a major jumping off point for gas pipeline construction workers. Communications and utilities would be impacted by the project, although project-associated communications systems may offer public/private multiple use opportunities throughout the route. Impact on the trade industries would be great, with gas pipeline and LNG plant construction providing extensive employment opportunities for tradesmen and laborers. Throughout the State, the project might also provide an opportunity for Native regional and village corporations to spin off new sector ventures.

Operation and maintenance activities of the proposed gas pipeline would have a direct stimulus impact on the state and regional economy. In addition, the existence of an operating gas pipeline would stimulate the exploration for additional natural gas reserves in Alaska in general and along the pipeline route in particular. This indirect impact, in turn, is expected to produce additional employment in the impact region and elsewhere in Alaska. When new oil and gas reserves are discovered, the resulting expansion of the Alaskan economy would be of further national and international importance.

A quantitative comparison of economic impacts of the several LNG route variations is possible through an econometric model of the State of Alaska developed by the University of Alaska. A wellhead gas price of $.50 and a production rate of 3.5 Bcf/d produces a wellhead value of $638.8 million, royalties of $79.8 million and a production tax of $25.6 million. For the Point Gravina route variation, construction employment reaches 7,572 in 1980, including pipeline, marine terminal and liquefaction plant construction; capital investment is $2.7 billion, yielding a property tax of $54.8 million, adding $396.9 million (1958 dollars) to real gross state product, $193.7 million (1967 dollars) to real wages and salaries, and $152.7 million to state revenues. By the time these construction impacts work throughout the economy of the state, their ultimate impact in 1980 includes an addition to employment of 23,800, population 32,800, personal income $555.7 million and per capita personal income $442 (Scott, 1975).

In summary, the proposed project would have beneficial impacts on the Alaskan economy in general and various industry sectors in particular. It would have major adverse economic impacts on the smaller cities that would be inundated by construction workers and their dependents and would strain the welfare and unemployment benefit centers of the government.

Sociological--Alaska's population is small (302,173 in 1970) and is primarily concentrated in the Anchorage, Fairbanks and Juneau areas. Major components of the population in Alaska during 1970 were: 17 percent Native, 83 percent non-Native. Although total numbers of people moving to Alaska are small in relation to the United States as a whole, their addition to the statewide population is major. A substantial segment of the population increase between 1970 and 1973 is believed to be directly related to the pending development of the trans-Alaska oil pipeline between the Prudhoe Bay Field and Valdez, Alaska. With start of actual construction of the oil pipeline system, population growth has been concentrated in Anchorage, Valdez, and Fairbanks. Historically, Alaska's population growth has been on the basis of in-migration associated with resource or military programs.

Absolute numbers of workers in Alaska to be involved in this gas transmission system are not expected to equal the peak numbers used on the Trans Alaska oil pipeline.

Construction of this alternative pipeline system would start after the completion of the trans-Alaska oil pipeline system which will be employing a peak of 14,000 to 15,000 direct workers supported by more than 20,000 people in service industries. Accordingly, it can be assumed that the gas pipeline system would have the long-term impact of maintaining or increasing the numbers of people living in Alaska and involved in the petroleum industry.

The impact on communities directly and indirectly affected by oil and gas development and pipeline construction would be primarily in the form of increased demand for public services and facilities. Most workers would be in construction or oil and gas field camps located away from the major communities. An exception would be the workers employed in terminal construction on Prince William Sound. Unemployment and indirect employment would develop at Fairbanks, Anchorage and the cities near the LNG plant which would also have to accommodate most of the dependent population. Because of their larger size and capability, Anchorage and Fairbanks would be able to absorb such construction and post-construction impact better than smaller communities.

During the peak impact period, severe strain would be placed on public services and facilities. Local housing probably would not be adequate for the population increase, therefore, the majority of the people would have to live in construction camps and dormitories, trailers and substandard makeshift quarters. Excessive crowding and lack of facilities would limit the length of time that unemployed job seekers, particularly those with dependents, would spend in Alaska. A markedly increased crime rate has already resulted because of the social turmoil created by this sort of stress. It would increase.

The present life style of Valdez, Ellamar, Tatitlek, Cordova, Whitshed and Crystal Falls in the Prince William Sound area would be changed by the cumulative effects of the oil and gas storage, conversion and transportation facilities to be built there. Because of the high wages many fishermen might abandon their present jobs and work on the projects. An increase in tanker and barge traffic with resulting shipping lanes closed to fishing would relegate fishermen to a lesser amount of habitat in which to fish and may force some out of fishing because of overcrowding or management regulations. If this happens, fishing towns could change to "bedroom" and service communities.

The construction and operation of this alternative pipeline could have a significant influence on Alaskan Natives. North Slope oil development fostered by the construction of two pipelines would become a major economic force accelerating and extending the cultural change process already very much in evidence. Although the oil activities probably would not introduce significant new elements into that process, they would increase the pervasive influence of the dominant American culture (USDOI, 1972).

The growing demand for material goods is a major feature that has resulted from the exposure of the Natives to the non-Native culture. Since these goods must be bought, the Natives have become increasingly dependent upon a cash economy. This, in turn, has resulted in a decline in the harvesting of subsistence resources and alterations in the nature and significance of the social institutions derived from that activity. Concomitantly, there has been an increasing requirement for the education and skills necessary for earning cash in the white man's world. As recently as 1967, a sample survey of rural Natives showed that less than one in four had transferred entirely to a cash economy.

The construction and operation of this alternate gas transmission system pipeline could entail significant negative impact on the resource utilization patterns of the Alaska Natives. The extent of this impact is largely a matter of speculation, but it is apparent that those Natives in the area of the Yukon River northwest of Fairbanks, and in the Copper River Valley area, are the ones who would be most subject to the disruptive forces (USDOI, 1972).

The potential pipeline-related causes of interference with the subsistence resource utilized by the Natives consist of disruptions to the habitat of fish and game as the result of construction or operational activities, and increased competition from the non-Native population for the limited available resources (USDOI, 1972).

Land Use--The gas transmission system starts in the Prudhoe Bay area within the oil development and transmission zone, follows the Federal-State Utility Corridor from its point of inception to an area south of Thompson Pass in the Chugach Mountains, and then proceeds to an LNG plant in the Cordova-Valdez area on Prince William Sound.

The 810 miles of the proposed facility passes through an undeveloped wilderness. The first 170 miles, from north to south, would be in the treeless tundra. Another 25 miles of tundra appears in segments as far south as mile post 565. At mile post 170 some small brush and trees are noticed. At mile post 190 some trees may be as much as 4-inches in diameter. The height, density and size of brush and trees increase farther southward. Trees with a 12-inch diameter start to appear in the vicinity of mile post 311. The last 33 miles of the proposed facility, in the Chugach National Forest, trees may be as much as 14-inches in diameter.

This route of the proposed facility would change unimproved land to pipeline right-of-way for the duration of the project. It would cross the proposed alignment of the Alyeska gas pipeline a number of places.

The land area which will be utilized on a permanent basis is estimated to be the following:

Twelve compressor station sites	216 acres
Pipeline right-of-way (809.2 miles long and 53.5 feet wide)	5,247 acres
Fifty sites for helicopter pads	10 acres
Fifteen sites for communication facilities	8 acres

Sites for four maintenance bases and two meter stations	26 acres
Sites for permanent storage of spoil from tunnel construction	100 acres
Roads providing continuous access to compressor stations (22 miles long and 50 feet wide)	133 acres
Roads providing access to construction camps and pipe storage yards (50 feet wide and 2 miles in length)	12 acres
Total area permanently removed from present land uses	5,752 acres

For the initial 767 miles this pipeline route would be basically parallel to the Alyeska gas pipeline and/or within the utility corridor designated for industrial land use. The route then passes through about 9 miles of terrain described as rough, sharp, choppy, flat and mountainous that supports dense medium timber to 12-inches in diameter and medium brush and timber to 4-inches in diameter before entering the Chugach National Forest. No cruise data are available to estimate the number of trees or amount of board feet that would be lost for the 33 miles of the route in the National Forest.

Additional land would be required to provide greenbelts for the 12 compressor stations (approximately 504 acres), the 15 sites for communication facilities (approximately 7 acres), and the 4 maintenance bases and 2 meter stations (approximately 9 acres). Such acreage would be utilized to provide additional work space during construction. On a permanent basis, the only maintenance to be performed would consist of minor vegetation control.

About 53.5 feet of the proposed 150-foot wide pipeline right-of-way would be kept clear of tall shrubs and brush after construction is completed.

Land ownership along this route is State (either patented, tentatively approved, or pending), Federal (under Bureau of Land Management or Forest Service jurisdiction), and Alaskan Native (selected, but not approved, under the Alaskan Native Claims Settlement Act).

The Alaska Native Claims Settlement Act provides for transfer of land and minerals to the Alaskan Native regional and village corporations that have identified lands they desire to be transferred.

Table 8.2.1-48 provides an indication of the ownership/jurisdiction along the pipeline.

The Alyeska pipeline project has required a large influx of people into portions of Alaska and has served as a catalyst for more land use planning, especially in the more urban areas. This trend would likely be sustained with the development of the natural gas pipeline proposal.

In addition to land required on a permanent basis for these facilities, the construction phase of the project would require the temporary use of more land. These lands are estimated to be:

Additional construction right-of-way on pipeline (96.5 feet wide by 809.2 miles long)	9,465 acres
Additional work space required at major river crossings	36 acres
Six construction camps (22 acres each)	132 acres
Borrow pits, quarries and other sources of construction materials	60 acres
Roads providing access to borrow pits, quarries and other sources of construction materials (50 feet wide and 226 miles in length)	1,370 acres
Major pipe storage and double-jointing yards at four locations	
Prudhoe Bay	20 acres
Pipeline Milepost 718	20 acres
Fairbanks	50 acres
Valdez	23 acres
Thirty-six intermediate pipe storage yards spaced at 20-mile intervals along the route	72 acres
	11,248 acres

Most of the route of the pipeline would be within the utility corridor designated for use for the Alyeska Oil Pipeline. In view of this, the impact of such activity on total land use in Alaska, would be minimal. The construction of the facility would require the removal of numerous trees the majority of which are not large or especially desirable as timber products by national standards. Most of the commercially valuable timber is in the southeast and is used in the pulp industry. Although the corridor cuts through some interior forest, it remains to be seen whether new access would establish new logging enterprises.

Perhaps the most significant impact would be the short term construction of the LNG plant and the pipeline in the Chugach National Forest. The serenity of the Forest would be disturbed by heavy equipment, cutting, felling and removal of trees, grubbing, burning of rubbish, and noises associated with digging, welding and building construction. Since the National Forest is recognized as a multi-purpose entity the recreational benefit of the Forest would be enhanced by providing an access corridor (the pipeline route), similar to a fire break, into a portion of the Forest. After construction, the impact of such facilities would probably be less than that of a public highway through a national forest in the conterminous United States except for the LNG plant site which would change the land use completely from forest/recreational to industrial.

Table 8.2.1-48 Ownership/jurisdiction along the pipeline

Jurisdiction	Miles	Percent
U. S. A.	615.2	76.1
Alaska	56.8	7.0
U. S. A. (Alaska Selection)	41.0	5.0
U. S. Forest Service	34.1	4.2
Varied	26.9	3.3
U. S. Military	17.7	2.2
USAF	10.6	1.3
Undetermined	6.9	.9
TOTAL	809.2	100.0

Source: Federal Power Commission, 1975, Vol. II

Archeological Resources--Any analysis of the impacts of pipeline construction on archaeological resources is limited by several factors. First, the precise alignment of the pipeline has yet to be determined. Second, the existing data are of variable quality with the archaeological reports often differing in format, methodology, descriptive precision, and in the qualifications of the reporters themselves. The result is that frequently the exact nature and locations of reported sites are not ascertainable. Third and most important, no comprehensive field survey has been performed for the pipeline corridor, hence the actual number and locations of the archaeological resources present in the impacted areas cannot be known. Indeed, the consultants have estimated that only 6 percent of the potential sites are known, leaving the overwhelming majority of archaeological resources yet to be identified.

While it is impossible to define with any precision the impacts of pipeline construction on Alaskan archaeology, what can be discussed is the nature of the impacts that can be expected along with an assumption of a worst case impact on the archaeological resources. The impacts associated with construction would be both direct and indirect. Direct impacts would arise from the actual construction of the pipeline and its associated facilities: the right-of-way, access roads, compressor stations, the LNG facilities and terminal, and contractors' camps and construction yards. The proposed right-of-way would be 150 feet wide with a normal ditch for the pipe of at least seven feet in depth and five to six feet in width. There would be a total of 12 compressor stations, four maintenance bases and the LNG plant and terminals. The activities associated with the construction of these facilities would include trenching, land clearing, the leveling of land in some areas by blasting, ripping and blading. Such activities would degrade and in many instances destroy any archaeological remains in the affected area.

Indirect impacts would arise from activities outside the actual construction of the pipeline. Foremost among these would be the greater likelihood of site disturbance from souvenir hunters as hitherto remote archaeological sites are exposed to human intrusion. Other indirect impacts could come about through soil erosion or chemical alterations in soils which would affect the integrity of archaeological sites.

Approximately 160 known sites have been located along the proposed pipeline route in a corridor 10 miles wide and 810 miles long. An additional 1,300 potential sites have been estimated within the corridor. Assuming the worst case, approximately 1,460 archaeological sites would be affected directly or indirectly by construction of the pipeline and its appurtenant facilities. However, it is much more likely that far fewer sites would be impacted with serious impacts limited to certain areas. The latter would seem to hold true for two areas. The second segment of the pipeline (see Section B) would pass through areas rich in archaeology and through terrain--Atigun Pass--where the feasibility of altering the pipeline route is severely limited. A second area of site concentration appears to be along segment nine from Delta Junction south to Copper Center, although along this route there is more room for rerouting the pipeline.

Historical Resources--The Sourdough Lodge at Sourdough appears to be the only National Register property that may be affected by the pipeline, although the route would pass to the west of the settlement. No other National Register properties appear to be endangered.

The Alaska Heritage Resource Survey lists 65 historic sites and 49 historic trails within the 10-mile by 810-mile pipeline corridor. Impacts of construction on these sites could result in the destruction of some or, in cases where compressor stations or maintenance yards are located nearby, in the permanent alteration of the environments around these sites. Since the pipeline would be buried much of the visual impact with the exception noted above would be short term, limited to duration of construction. In some cases however, where sites are in wooded areas for instance, the land clearing of the right-of-way would produce a more permanent visual intrusion.

Recreation and Esthetics--This transmission system would extend from Prudhoe Bay to Gravina Point through an existing utility corridor for most of its length and through an unoccupied area of the Chugach National Forest for the remainder (46 miles).

Recreational use along the road associated with this route from Livingood south to the Valdez area is heavy. The recreation facilities are primarily highway oriented and many more are proposed (see Description of the Environment). From Fairbanks north to the Yukon River, recreation use has been increasing rapidly because a portion of the oil pipeline road was constructed several years ago and is open to traffic.

The area from the Yukon River north to Prudhoe Bay has only seen light recreational use, consisting of fly-in type recreation primarily for hunting and fishing. When the new road associated with the TAPS Project is open to the public, recreation use along this scenic route is expected to increase.

The proposed gas pipeline route runs parallel to, or a few miles away from, the main road along its route. Lateral access roads from the existing highway to the proposed route would, if open to the public, very likely be used by recreationists. This access would extend the area and amount of use that already exists and could significantly increase the recreational opportunities.

During construction, there would be moderate recreational use of areas along the pipeline by construction workers. Desirable recreation for travelers and vacationers on highways along the route might be temporarily altered during the construction period. Most of the recreation activity would occur in the late spring, summer, and early fall months. However, there would be some increased use even in the winter months where roads are kept open and maintained.

Recreation use includes hunting, fishing, boating, hiking, mountain climbing, cross-country skiing, snowmobiling, sightseeing, photography and other similar related activities. Unless steps are taken to provide adequate recreation facilities, campgrounds, picnic areas, overlooks, boat access sites, trail leads, parking areas, turnouts and rest stops, damage to the terrain from uncontrolled recreation use and a general degradation of recreation and esthetics could result.

Such facilities as the communications towers, buildings at compressor sites, the block valves ports, etc., would be visible from the ground for great distances. At times, even the pipeline mound would be visible from great distances to those hiking in the mountains. Lights on communications towers and at compressor stations would be visible over long distances at night.

The regular (i.e., non-natural) shape of compressor site gravel pads, airstrips, and roads would give man-made appearance to the present natural landscape.

The degree of acceptance of many of these impacts would vary according to the individual perceiving them. For example, the presence of pipeline-related airstrips would be considered desirable by reactionists who feel this "safety feature" in emergency situations is necessary to a reasonable recreational experience. Airstrips would be adverse for those wishing maximum wilderness as a part of their recreational experience.

Without defined trails (the present situation), it is possible that hikers and skiers would pass over borrow pits, access roads, quarries, and other off-the-pipeline right-of-way disturbances as well as the pipeline itself. Those passing over the pipeline would see the exotic plants used to stabilize the pipeline ground cover.

Boaters on and hikers near rivers might notice places where the pipeline crosses rivers and might have their recreational experience affected by barge traffic and gravel extraction sites.

Artificial odors would be evident from engine exhaust, fuel areas, and camps.

It is expected that air quality would be affected by the operation of the construction equipment. The release of water vapor from the construction and operation activities would probably be sufficient to create periodic fogging and icing conditions in and adjacent to the pipeline right-of-way and maintenance station pads.

Wildlife populations would be affected by the construction and operation of the proposed project and by increased pressure from hunting and/or "viewing" harassment. This would reduce the total numbers available and reduce the recreational potential of the area.

The impact of the pipeline activity would serve as a catalyst to open-up many planned and unplanned frontiers of recreation opportunities and experiences for people who would be attracted to the area because of increased access.

Unregulated use by all-terrain vehicles, trail bikes, snowmobiles, and other off-road-vehicles could have a significant adverse impact on recreation and aesthetics by permanently scarring the landscape, damaging the vegetation, compacting the soil, causing erosion, and harassing the wildlife.

With increased awareness of recreational opportunities created by pipeline-related activity, there would be increased recreational use and demand for recreational facilities with the attendant impacts described above. It is anticipated that this will also be reflected in the 1975 Alaska Staff Comprehensive Outdoor Recreation Plan (SCORP) when it is released. New recreational resources would be discovered with resulting demands for explcitation and/or preservation. Impacts on the Chugach National Forest would include increased recreation use and demand for facilities which would be in the direction of achieving a multi-purpose justification for the Forest.

Project increased recreational use assumes that gas pipeline construction and operation would bring increased potential for recreational use of the area because increased numbers of people will become aware of the recreational possibilities of the area through publicity and personal association (employees). Increased use will inevitably bring increased control; thus, recreationists might experience such things as reservation systems, reduced options for types of experiences, and restrictions on places they may go and their length of stay.

A more direct impact of the construction of the alternative pipeline on the recreation resource would be the scars resulting from the buried pipeline construction or the visual impact if certain areas had to be located aboveground. In all cases this gas pipeline would be at least a "third" utility to be located in a corridor area, consequently it is not like building a new line across an area previously undisturbed by man.

Nearly all the proposed line south of the Brooks Range would require the clearing of brush and forest cover. This would significantly alter the natural environment and would degrade recreation value of the corridor particularly where long straight clearings are visible from the road.

Recreationists within several miles of the line would have their recreational experience affected by increased noise levels from construction and operation of the line.

This transmission system would be built in a utility corridor, with an existing road, railroad or with other utilities except where it crossed the undeveloped area of the Chugach National Forest. Esthetic impacts would be significant in the forest.

Many of the esthetic impacts have already been discussed under recreation. The major impact to many people would be those features seen from the air, during hiking, driving on the main roads, and boating on rivers. These would include the long straight clearing along rights-of-way, compressor stations, special stream crossing facilities and any borrow areas that are not hidden from view.

For those people whose appreciation of esthetic qualities are those related to beauty, sensations, or to the congruity of the environmental features, the proposed project would have a significant adverse effect on the resource.

Increased Noise--Compressors would be audible for 6,000 to 7,000 feet and the degree to which their noise annoys people would depend on their location with respect to human habitation. Periodic venting of high-pressure gas from the pipeline and compressor stations would cause temporary, but severe, increases in sound levels. These maintenance checks on emergency blowdowns would occur about once a year and last for 45 minutes on the pipeline and 5 minutes at the compressor.

The noise level from gas blowdown was high and was estimated at a maximum of 140 dB(A) at a distance of 100 feet from the stack. This noise occurs infrequently, however, and with a stack silencer it could be brought down to 80 dB(A).

The additional noise from the gas collection and processing facilities at Prudhoe Bay would contribute to other operations related to oil production.

Where the pipeline passes near towns and farms, construction equipment noise could be quite loud and annoying to many people. There are at present no Federal regulations specifying permissible noise levels for stationary gas turbines.

Short-term noise would result during construction from blasting (temporary and short-term), aircraft, vehicle, and compressor operation (nearly continuous and lasting throughout the life of the pipeline).

Ambient Air Quality--The gaseous pollutants from compressor stations along the route consist of combustion products, mainly nitrogen oxide and hydrocarbons. There may be intermittent emissions of hydrocarbons particularly methane as a result of leaks, venting and other accidental emissions. Sulfur dioxide and particulate emissions from compressor stations are very small. Typical emissions are tabulated in the following:

Emissions From Gas-Fired Turbines
in Compressor Stations
(lbs/MMBTU)

SO_2	0.01
NO_x	0.69
CO	0.04
Particulates	Trace

Since these are within the limits of any known standards of the Alaska Environmental Protection Agency, the applicant has not incorporated any special measures to further mitigate such emissions.

LNG Transport (Marine Route)

Climate--The proposed project should not have a significant impact upon the climate of the marine environment.

Topography, Geology, Soils, and Water Resources--Proposed facilities whose construction would affect the marine environment are the 600-foot long access road/breadwater structures, liquefaction plant and associated structures in the Gravina Point area, the breakwater structure, vaporization facility and associated structures in the Point Conception area and the LNG tankers operating between the two parts.

Construction and site preparation operations such as clearing surface vegetation and grading the site in the Gravina Point area would result in increased erosion and potential leaching problems. The magnitude of this impact is potentially increased because of the large amount of precipitation that falls in the vicinity of Prince William Sound. Erosion would increase the silt content of Harris Creek and local estuarine areas. Construction-related petroleum products spills might also impact marine biota by the introduction of these products into local watercourses via runoff.

Sediment produced by the construction activities would reach marine-waters in Port Gravina and Orca Bay. The effect in Port Gravina would be locally significant at river deltas whose basins are crossed by the proposed pipeline route. This local impact should be short-term, during and for 1 to 3 months after construction if proper erosion-reduction measures including revegetation are successful. In Orca Bay, overland drainage through Harris Creek would have a significant local impact due to clearing, stripping and other construction activities at the proposed LNG terminal site. Some sediment would be carried by Harris Creek from the pipeline construction in its basin. There would be an increase in erosional processes because of unprotected ground surfaces and the large amount of precipitation that falls in the area. This would increase the silt content of streams and estuarine areas to the detriment of freshwater and marine organisms.

Some fine sediment which would be entrained due to construction activities in the Lowe River Basin may reach the Valdez Arm. Its impact there should not be significant.

Offshore construction of the proposed marine terminal would further result in temporary increases in turbidity.

The magnitude of impacts associated with the construction and existence of a proposed 600-foot long access road/breakwater and the proposed LNG terminal's wastewater discharge is dependent on local nearshore circulation. Because baseline information on nearshore circulation is insufficient, these impacts cannot be accurately assessed. However, the breakwater would affect local circulation patterns, and if circulation patterns in Orca Bay are such that waste discharges are concentrated, adverse effects to the waters of the bay would result. Expected characteristics of the operational waste discharge are presented in Table 8.2.1-47.

Spills of toxic substances such as acrolein or hydrogen chloride during plant operation could result in degradation of water quality.

A tanker collision or grounding in the area of the plant site could release Bunker "C" fuel oil carried on the tanker. The adverse effects would depend on spill size, spill location, and existing meteorologic and oceanographic conditions.

In Prince William Sound the operation of the proposed LNG plant would withdraw about 658,000 GPM of water from Orca Bay into the plant for the proposed once-through cooling water system. The effluent would be discharged by means of a pipe which would extend into Orca Bay and discharge at a depth of approximately 60 feet. Current specifications call for the effluent to be approximately 21°F above the ambient seawater temperature. Chlorine to be used as an LNG liquification facility anti-fouling biocide and brine from desalinization facilities would also be mixed into the effluent prior to its discharge into Orca Bay.

The Point Conception proposed facilities that would involve construction and operation related impacts on the marine environment include the 4,600-foot long pile supported trestle and pier terminating in a water depth of 60 feet (above MLLW); a break-water-protected harbor for small boats, which would be located on the east side of the pier in approximately 20 feet (MLLW) of water; the intake and outfall structures for the heating seawater system; and a screenwell and fish return system.

The small boat harbor would consist of a rock breakwater which would be connected to the trestle via a roadway on top of the breakwater. The "U" configuration of the breakwater would be approximately 1,000 feet long. The boat harbor would be used as a construction dock during the LNG terminal construction phases. During plant operations, the harbor would shelter tugs, barges and other small craft. The height of the breakwater would be determined after meteorological and oceanographical study of the site has been conducted. The appropriate type of breakwater to be built at the site would be determined following model and resource studies. Regardless of the type of breakwater, floating marine construction equipment would be required. Hauling barges would transport the materials to the site and floating barge cranes would be used to place the materials.

Trenching or dredging would be required in the surf zone for the construction of both the seawater intake and outfall structures. This could cause disturbance of low density sediments. The proposed breakwater could affect local circulation patterns and could locally affect the littoral transport of sediment in the nearshore zone. Increases in turbidity may be the result of changes in wave refraction caused by the breakwater and marine trestle.

Discharge of freshwater used for hydrostatic testing of the LNG storage tanks and any dewatering at the plant site would produce temporary impacts resulting from salinity and temperature differentials between the effluent and the receiving water.

A tanker or barge collision or grounding in the area of the plant site could release Bunker "C" fuel oil. The adverse effects would depend on spill size, spill location, and existing meteorologic and oceanographic conditions.

The vaporization facility would be close enough to the shoreline so that construction wastes, spills or leaks from this portion of the project could reach the sea via the Canada del Cojo as runoff. Construction and site preparation operations associated with the vaporization facility would result in increased erosion. This could increase turbidity in nearshore coastal waters. Offshore construction would further result in temporary increases in turbidity.

The biocide acrolein would be added to the seawater intake at an average rate of 0.6 parts per million for 4 to 6 hours per day to inhibit fouling of the system by marine organisms. The acrolein would be neutralized by a stoichiometric quantity of sodium bisulfite prior to discharge back to the ocean.

Under base load operations, approximately 300,000 gallons per minute (gpm) of water would be circulated through the seawater vaporization system. The water temperature would be depressed 12°F in the vaporizers. Acrolein would be added in 0.4 to 0.8 parts per million (ppm) concentrations for 4 to 6 hours per day to inhibit fouling by marine animals. The cooling water would be detoxified before discharge by the addition of sodium bisulfite.

If accidentally spilled, the acrolein could enter the marine system and kill organisms in the area. The damage from such an accident would depend on the amount of acrolein spilled, location of the spill, and the effectiveness of emergency cleanup and neutralization procedures. Data from the producers of the neutralizing agent, sodium bisulfite, indicate that this solution, normally 35 percent by weight, has a pH of 4.0. Direct contact with such an acidic substance could be expected to cause discomfort and burns in both humans and marine organisms.

Due to the intermittent addition and neutralization of the acrolein, no significant effects of the biocide should occur in the open sea during normal operations of the plant. A system to stop and neutralize the acrolein input in the event of failure of the neutralizer addition system would be provided.

If fuel gas firing is used, 15 gallons per minute of acidic (pH 5.5), freshwater overflow would be generated. It would be diluted and discharged through the 300,000-gpm seawater discharge pipelines. The desalination unit would produce 235 gpm of high salinity (about 1.1 times ambient salinity) return water and an average of 0.5 gpm of blowdown water from the boilers used in the flash distillation unit. Storm runoff from the process area is expected to average 135 gpm.

If contaminated with oil, drainage from the diked oil storage areas would be processed to remove the oil before being added to the holding pond. A small volume (not to exceed 5 gpm) of fresh cooling water from the utility and instrument air compressors may periodically be added to the holding tank. An average of 7.3 gpm of sanitary waste water from the combination of raw sewage and oil-contaminated drainage, which has been processed through activated sludge treatment and a chlorinater, would also be added to the holding pond. These discharges may be combined with the heating water return system or discharged directly into the ocean. No adverse effects would be expected to result from these minor additions.

When fuel firing is required, freshwater would be used in the heat exchange system. The volume of this water is not known. On return to base load operations, this freshwater would be stored, discharged into the holding pond, or added to the heating water discharge. Until the volume and means of discharge are known, however, the potential impact of this waste water cannot be assessed.

The "Water Quality Control Plan, Ocean Waters of California" (California Regional Water Quality Control Board, adopted July 6, 1972) is the controlling regulatory document for treatment and discharge of waste water into the marine environment along the coast of California. Treatment and discharge of effluents from the proposed LNG facilities would comply with regulations set forth in this document. Existing California Regional Water Quality Control Board regulations governing temperature differentials between the receiving water and the effluent do not apply to cold water discharges.

Vegetation, Wildlife, and Ecological Considerations--Due to the lack of baseline oceanographic data, temperature tolerance studies of the marine life inhabiting Prince William Sound, and the design features of the effluent outfall, neither the areal extent and magnitude of the influence of the thermal discharge nor the specific impacts on marine biota are known. However, some general comments can be made.

In general terms, several potential biological responses would result from thermal stress. Thermal stress may (1) cause motile organisms to physically remove themselves from the stimulation, (2) cause physiological adjustments to compensate for the temperature change, (3) cause the organism to assume some protective position or behavior, or (4) cause the organism to succumb. Persistently elevated temperatures have been suspected of causing other behavioral changes of species such as (1) alterations in natural vertical movement of organisms due to vertical stratification of the water column, (2) avoidance of thermal barriers in spawning and nursery areas, (3) seasonal changes in spawning and development, and (4) alterations in migratory behavior of anadromous fishes in coastal areas.

Disease organisms also respond to temperature by causing excessive losses to fish life. Heat shock, which can result in the fishes' loss of equilibrium, can occur when the fish is brought rapidly from lower to higher temperature. Because of the effects of temperature on dissolved gas equilibrium in water, oxygen deficiencies can be created and nitrogen embolism can be caused. Swimming speeds are altered by changes in both temperature and oxygen concentration.

The presence of heavy metals or chemical discharges during the descaling operations at the proposed LNG plant would be toxic to organisms living in the discharge area.

Within certain limits, the rate of change in temperature may be of greater significance to the survival of an organism than the amplitude of the change. If the shutdown of the proposed LNG facilities would result in a sudden temperature change in the area affected by the warm water discharge, insufficient time would be allowed to affect physiological compensation reactions to the thermal stress. Knowledge of the effects of this type of thermal stress has been employed as a means of harvesting cultured salmon.

These general biological effects may be expected to be produced in several significant species of marine biota due to the proposed LNG facility warm water discharge. Adult pink and chum salmon and to a lesser degree, silver and red salmon migrate past the proposed Point Gravina site in large numbers during July and August. Of particular potential significance is the migration of pink salmon juveniles during the period of May through July. These young fish migrate at the water's surface and from 100 to 500 yards offshore.

On the basis of information available at this time concerning the proposed location of the heated water discharge outfall, it appears that the juvenile pink salmon migrations would encounter water, the temperature of which was significantly elevated above ambient due to the warm water effluent.

Additionally, large numbers of Tanner crabs, King crabs and, in smaller quantities, Alaskan pink shrimp are commercially harvested in the vicinity of the proposed LNG terminal. Those species could be impacted by the proposed heated water effluent in any of the several ways indicated earlier. Also, seaweeds and sea grasses, two important groups in Prince William Sound, are quite sensitive to changes in seawater temperature.

The proposed thermal discharge would exceed temperature elevation limits established in the water quality criteria for the State of Alaska. These criteria state that in coastal waters temperatures may not exceed natural temperatures by more than 2°F. In order for the applicant to discharge the seawater cooling effluent as proposed, a permit would be required from the State of Alaska.

Impacts due to the operation of the cooling facility would also occur on marine biota by means not directly related to the warm water effluent. Plankton, including plant and animal, and larval and juvenile forms of fish and shellfish that would be drawn into the cooling system would experience nearly 100 percent mortality. The impact of this on juvenile and larval stages of salmon, shrimp and crabs is potentially severe.

Chlorine is proposed as an anti-fouling biocide. The applicant indicates that the residual chlorine content of the effluent from the seawater cooling system would be "less than or equal to 1 ppm." According to the U.S. Environmental Protection Agency's Proposed Criteria For Water Quality (1973), concentrations of free residual chlorine in marine or estuarine waters in excess of 0.01 ppm are unacceptable. Fish may avoid chlorine in concentrations as low as 1 ppm but, if locked into a situation where chlorine is present at levels of 0.1 ppm, they may choose to remain there, although the concentration may finally be lethal.

In addition to the impacts associated with operation of the LNG plant, there are two potential impacts on fisheries in Prince William Sound that would result from the LNG tanker traffic. The proposed tanker route would cross one of the most productive tanner crab areas in Prince William Sound. Crabbing within the tanker route would be prohibited since the tankers would remove the marker buoys which are attached to crab pots located on the bay bottom. The crab pots which are used to capture the crabs would then be lost to the fishermen. The removal of this crabbing area in the tanker route would reduce the area available to crabbing. The areal extent of tanker influence to the crabbing activities would normally be confined to the 1-1/2 to 2 mile wide traffic lane within Prince William Sound.

There is also the possibility of a tanker straying from the traffic lane and into the crabbing gear. This would not only be a financial loss to the fishermen, but there is some evidence that pots which are lost continue to catch crabs until the trap eventually rusts open. A significant number of crabs could be lost in this manner if enough traps are cut from their buoys.

Netting salmon by means of a net stretched outward from the shoreline is a popular form of fishing in the Gravina area. This activity could be impaired as a result of waves generated by the passage of tankers close to these fishing areas. This wave action could be of sufficient force to damage the nets and other related gear left on the beach.

The construction of a terminal at the Point Gravina site could result in the abandonment of some or all of 16 bald eagle nesting sites known to occur in this area. The terminal itself would not displace more than three to four nesting pairs, however the associated high level of vessel traffic would be the critical factor.

Seabirds would be impacted by the same range of effects as the mammals with particular potential threats from "spills" and vapor clouds in the vicinity of the terminal.

It appears that many seabirds could outfly a vapor cloud by gaining altitude, but it is not clear that this is how they would react. Many seabirds are poor fliers and their natural instinct is to escape a hazard by diving and later surfacing to fly away. Also the rapidity with which a large spill propagates leaves some doubt that birds near the origin could outfly its associated effects. In addition, a number of seabirds are flightless for a time after their post nuptial molt. Immature seabirds such as common murres leave their breeding cliffs before they are thermoregulated and before their flight feathers have erupted. If a large spill occurred in an area where shorttailed shearwaters were feeding in the densities reported by Shuntov (1964) there could be as many as 26,500 birds of this species within an impact zone. Another potentially disastrous situation is the possibility of a spill occurring adjacent to a breeding colony.

While the magnitude of environmental impacts in the marine ecosystem appears of minimal potential, marine mammals could be affected by the pool and vapor cloud or fire.

The scale of the impact would be in direct proportion to the number of animals caught within the zone of the spill pool. An unknown aspect of the spill is the speed of propagation of effects of the spill within the water column. It is possible that any of the larger more mobile species could evade the impact.

A sperm whale for example evades danger either by sounding or by swimming rapidly away. Sounding is the most common method of evasion and often when one sounds it is not seen again. Rice has timed one large bull which remained below for 62 minutes. Sperm whales which leave an area by rapidly swimming away usually swim into the wind (Caldwell, et al., 1966). There is little doubt, therefore, that a sperm whale is capable of evading even a large LNG spill. The unknown is the behavior response of a sperm whale in a spill zone.

The giant bottle-nosed whale is another species with the physical stamina to evade a spill. Among the other cetaceans there is probably a whole range of ability to evade a spill. Some of the porpoises and other marine mammals such as the sea otter, seals, and sea lions could possibly not avoid such a catastrophe.

Emplacement of breakwater would cause an almost complete mortality of the slow-moving and sessile organisms, the infauna (organisms living in the substrate), and the benthic plants which are present at the site. The more abundant invertebrates in the immediate area which probably would not survive the breakwater construction include abalone, hydroids, anemones, and several species of starfish. Less common invertebrates include sea urchins, rock crabs, and lobster. The area is on the nearshore edge of the kelp beds. Characteristic algae in this transition zone which would be destroyed include Macrocystis (giant kelp), Egregia (feather boa kelp), and possibly some Pterogophora (a brown algae).

Sediments suspended as a result of rock placement activities could have several detrimental impacts on organisms in the area immediately adjacent to the activity. Suspended particles can clog the filter feeding and respiratory mechanisms of many animals. Their eventual death can result from simple abrasion from sand particles. As the particles settle out of suspension, benthic organisms may be buried. The motile organisms such as fish would move from the construction area and avoid serious damage. Some of the sedentary or slow benthic organisms are adapted to shifts in seafloor materials, but their survival would depend on their mobility, and the rate and volume of settling material. With increasing distance from the breakwater, the possible effects described above would diminish. Until more adequate information is supplied about the proposed structure and the physical oceanography, further assessment or quantification of construction impacts from the breakwater emplacement will not be possible.

The impacts associated with installing the trestle pilings would be similar to those described above for the breakwater placement. The area of impact involved under each of the piles would be considerably less; however, due to the linear extent of the trestle, more habitat types and associated biological communities would be impacted. It is expected that the impacting of several small areas over the length of the trestle would not, in itself, constitute a significant threat to the populations of plants and animals in the vicinity of construction activities.

Boat and barge activities during construction would cause the loss of the kelp canopy in the vicinity of the breakwater and pier installations. The physical cutting of the kelp fronds would decrease primary productivity in the immediate area. However, the loss of kelp production may not be significant because frond regeneration is rapid and because increased light penetration would allow increased phytoplanktonic production. Nutrients released from sediment disruption may, given sufficient oxygen, further increase primary production. In any case, the net short-term productivity change should not be significant.

Adequate information on design, location, and construction procedures of the seawater intake-outfall system and the screenwell are not available to accurately assess the impacts which would be associated with this aspect of the proposed construction of the vaporization facilities. However, dredging would be required in the surf zone to construct the intake and outfall structures. Such dredging would destroy habitats and organisms in the vicinity of the dredging operations. In addition, impacts from sediment movement and increased turbidity would be similar to those discussed in relation to the breakwater construction. Because the dredging would be in the surf zone, the organisms affected would include intertidal flora and fauna as opposed to neritic organisms. The significance of the impacts from constructing the intake-outfall structures is not known and it is the staff's opinion that any speculation on the significance of such impacts would be unfounded without more information on the structure design and construction procedures.

Freshwater would be used for the hydrostatic testing of the LNG tanks and any water collected from dewatering at the plant site would be discharged into the marine environment. About 11.5 million gallons of test water would be required for each tank. If scheduling permits, the same water could be used to test all tanks. Measures should be taken to minimize adverse effects on the marine environment.

The discharge of at least 11.5 million gallons of water into the sea would locally reduce the salinity of the ocean water. The amount of salinity reduction and the size of the area affected would depend on the rate of discharge, the water current patterns, and the ultimate volume discharged. The impacts on the physical environment, such as habitat destruction, would depend on the discharge techniques used. The impacts on the marine biota would also depend on the discharge techniques and on the organisms located in the area of reduced salinity. Some organisms can move from the area. Others can close themselves off from their surroundings and thereby avoid the lower salinities. Some organisms can tolerate lower salinities for short durations while others cannot.

The breakwater would be installed early in the construction phases to allow the boat harbors use as a construction dock. During the lag between completion of the breakwater and startup of plant operation, the areas impacted by the breakwater construction would partially recover. A period of 2 to 5 years may be required before a biologically recovered (breeding) community is established. The breakwater would be a high-relief object, as would the trestle pilings, and would be able to support a greater abundance and diversity of organisms than in low-relief or sandy areas.

The breakwater would indirectly create a relatively low energy environment within the berthing area as a result of the breakwater induced changes in wave and current movement. Therefore, the creation of this breakwater habitat should lead to the development of a biotic assemblage characteristic of southern California's protected, rocky areas. On the seaward side of the breakwater, biotic communities typical of high-energy rocky areas should develop. However, should the cold water plume from the seawater outfall encroach on the breakwater, the communities developing on the breakwater could change. See the discussion of the cold water plume for additional information.

Under base load operations, approximately 300,000 gallons per minute of sea water would be circulated through the vaporization system and returned to the ocean. The kinds of impacts of cold water on marine organisms are dependent on the difference of temperature between the effluent and the ambient water temperature. The extent of the impact depends on the size and shape of the plume. No studies on the biological effects of cooled seawater discharges are available for comparison with the proposed system. In addition, the location and design of the outfall has not been specified. Its location relative to biotic distribution, current patterns, and natural temperature distributions would have a significant effect on the resulting impacts. Until the location and design is specified, impact assessment can only be general.

Point Conception is regarded as a natural boundary between the colder water regimes of central and northern California and the warmer waters of southern California. At the boundary itself, the conditions can be expected to vary more than they do to either side, thus the biological community found at the boundary is a mixture of the northern and southern species.

Seven hundred and twenty-one species of vertebrates, invertebrates and algae known to or likely to occur at the Point Conception site were categorized by Dames and Moore (1974) on the basis of zoogeographic range data into northern, southern, and transitional groups. Approximately half (48.1 percent) of these species were determined to be in the Zone 1 (northern) group; 35.2 percent fell in the Zone II (transitional) group; and 16.7 percent formed the Zone III (southern) assemblage.

Dames and Moore (1974) indicated that Zone I species should be able to tolerate depressed water temperatures of the magnitudes experienced around the cold water outfall. Zone II species were expected to acclimate to the depressed temperatures in most instances and all species were expected to be able to survive outside of the -2°F isotherm. Zone III species were not expected to tolerate greatly depressed temperatures.

Physiological effects of cold on marine poikilotherms are primarily manifestations of reduced metabolic rate. One effect of this reduced metabolic rate is the reduction in growth rate of both larvae and adults (MacLaren, 1965; Scheltema, 1967; Loosanoff, and others, 1951; and Bullock, 1955). Another effect is the increased size of animals in cool water populations when compared to warm water populations of the same species (MacLaren, 1974; Bullock, 1955; Fox, 1939; and Dehnel, 1955). As fecundity is directly correlated with size, increased size leads to greater fecundity (Dehnel, 1955; MacLaren, 1974; and Patel and Crisp, 1960).

A permanent decrease in ambient temperature as opposed to short-term cooling may result in a restricted or absent reproductive period in those species where reproduction is cued by higher temperature or by longer periods of temperature above a certain level.

Maximum temperature stress is expected to occur during the winter when temperature minima prevail. Species could suffer lethal temperature effects, resulting in reduced population size.

According to Dames & Moore, the general effect of cooled water will be to force a change in the species composition of areas directly influenced by the effluent.

The entrainment system consists of a screenwell inside of the intake pipe, a trash rack, and traveling screens. The initial entrainment of organisms would kill most and stun some of the larger organisms. Those few larger organisms which move through the system unharmed could return to the sea through the screen wash system which would discharge into the surf zone. However, most of the organisms which are trapped by the screens and pass through the fish return system would probably be injured. These organisms would not be expected to survive because they would be easy prey, and injured organisms often succumb to diseases. Even a surficial scratch can prove fatal through disease. Velocities of traveling screens should be kept low to minimize damage to large marine life.

Marine birds that feed on dead or stunned fish would congregate near the discharge end of the return system. A group of fishes may congregate or reside at the mouth of the screen wash return to take advantage of partially immobilized animals. Such predation may be considered beneficial to the predators and may reduce the amount of detritus created by dead organisms washing into the sea.

It is anticipated that there would be nearly 100 percent mortality of plankton, eggs, and larvae which pass through the vaporizers. The temperature shock and mechanical abrasion alone would probably be sufficient to kill many species of plankton and the intermittent addition of acrolein into the heating water would kill the remaining organisms prior to adding the sodium bisulfite as a neutralizer.

Relatively insignificant losses of surface kelp would result from LNG ship and small-craft operations. With the head of the pier in 60 feet of water, the outer edge of the existing kelp canopy would be inshore of any normal LNG ship operations. Since the small boat harbor is within the kelp zone, some losses of surface kelp would be expected as a result of barge and tugboat activities.

LNG tankers are constant draft ships. To maintain proper trim, an equivalent weight of seawater must be taken on board for each increment of LNG discharged at the terminal facilities. This process would be reversed at the LNG onloading facilities in Alaska where ballast water would be discharged as LNG is loaded. Ballast water may serve as a medium of transport for southern California planktonic marine organisms to the Alaskan LNG loading sites. Impact of ballast water uptake at the marine facilities is limited to the removal of plankton contained in the ballast water.

Diesel fuel and Bunker "C" fuel oil would be shipped by barge to the proposed site. Bunker "C" fuel oil would be onloaded to the LNG ships at the LNG unloading platform. The effects of oil spills on marine biota are varied and dependent on a number of parameters, including size of spill, type of oil, length of exposure time, oceanographic and meteorological conditions, and cleanup and containment operations.

Impacts can be decreased by effective operational procedures and containment and removal of any spilled oil. Cleanup or oil spill containment contingency plans would be developed for this site. Because of the lack of extensive rocky intertidal areas within the immediate site it is expected that damage to the biota of this area would be minimal. However, damage would probably be severe to the biota which develops on the breakwater areas, as well as to the surface feeding marine birds known to occur in the site area.

Economic Factors, Sociological Factors, Land Use and Paleontological, Archaeological, and Historical Resources--This section of the statement pertains to the marine route only. The above factors are applicable to land masses and are discussed under appropriate sections of the statement pertaining to the Alaskan and California sections of the statement.

Recreational and Aesthetic Resources--Construction of the marine facilities would have a direct, conflicting impact on recreational and commercial use of offshore areas. The construction activities associated with the installation of docking facilities and trestles on subtidal land, would impose temporary localized restrictions on any vessel using the area. Commercial fishing boats in the area would have to exercise caution to avoid interfering with construction activities and to avoid any possible collisions or damage due to trawling equipment such as nets and otter boards. Recreational vessels would also run the risk of collision with barges, other construction vessels and LNG tankers. Kelp harvesting would be excluded within the immediate vicinity of construction.

Within the inshore areas, where recreational use is more significant, several impacts would occur. Any swimming, scuba diving, surfing, and other beach-related activities would be eliminated.

The shoreline that extends from Jalama to Gaviota Beach, California is some of the most scenic in the county. The development of a designated scenic corridor would be dependent on the design and development of a shoreline drive. The proposed LNG terminal would degrade the quality and effect of such a plan along the coastal terrace. This impact would affect not only the present residents of the Hollister Ranch area but would affect the general public who would gain visual access all along the scenic corridor.

Air Quality and Environmental Noise--The proposed project should have an insignificant impact upon the air quality or noise of the marine environment. However, the release of liquid natural gas from ruptured tankers or pipelines associated with the Liquefaction plant near Gravina Point or the regasification facilities at Point Conception are potential hazards to the environment.

The most significant hazard that could occur during the operation of the proposed LNG terminals would be the formation of a combustible vapor cloud and its subsequent dispersion and drift downwind into populated areas. The vapor cloud would be formed as the result of a spill of LNG. The larger the spill, the larger the vapor cloud and the further it could travel downwind over populated areas. A spill could occur over water from an LNG ship collision, or over water from a rupture of an LNG pipeline.

Although there is little actual experience with the hazards to the public from LNG import terminals, there are data available from experiments involving small LNG spills, and analytical techniques for calculating vapor dispersion and drift. There is also available the accident experience involving the marine transportation and land based storage of other flammable liquids. This material has been used in the analysis given here. Some of the properties of liquid methane, which is the major component of LNG follow:

Molecular wt. = 16. gm/mol
Density of gas @0°C = 0.717 gm/liter = 0.451 lb/ft^3
Density of gas @112°K = 1.75 gm/liter = 0.11 lb/ft^3
Density of liquid @109°K = 415 gm/liter = 25.9 lb/ft^3
Boiling point = 112°K = -161°C = -260°F
Heat of vaporization = 138 cal/gm = 248 Btu/lb

To assess the risk of casualties near the proposed LNG terminal in Prince William Sound, Meteorology Research Inc. has performed an analysis which includes the effects of a massive (2,000,000-gal) LNG spill from the storage tanks at Point Gravina onto water. Plume analyses were made on seasonal and annual bases for this site using climatology data and a Gaussian model for plume dispersion. For 5 mph winds the flammable plume extends about 9 km (5.6 miles) downwind, which is predominantly from the east the year round. The population at risk to such a plume is believed to consist of plant employees, ship personnel, and fishermen in the vicinity, and is estimated to be less than 100 people.

The Federal Power Commission (1974) has classified spills as small (10 cubic meters), intermediate (25,000 m^3) and large 100,000 m^3). Small spills result from operational problems such as leaking flanges, the intermediate spills such as puncture damage to one tank, and a large spill would be comparable to rupture of more than one cryogenic tank.

The small spill of 10 m or less would result from a lapse in attention to operational procedures or from damage to a flange or failure of its gasket, etc. It would most often take the form of a leak. The LNG lost in a small spill would warm very rapidly and escape into the atmosphere.

The calculated time to evaporate a spill of 10 m^3 is 0.4 minutes (Fay and MacKenzie, 1972). A leak totalling 10 m^3 over a period of time would for all practical purposes evaporate almost instantaneously. The buoyancy of methane once it has reached the gaseous state assures its quick dispersion. Methane-air mixtures have a flammable range of 6-13% at -130°C and 5-14% at ambient air temperature (Burgess and Zabetakis, 1962).

The greatest hazard in the case of a small leak is the potential ignition of the methane as it passes through the flammable range. Methane is defined as nontoxic gas. In a confined space it could exclude enough oxygen to make asphyxiation possible but this should not be a problem in the open atmosphere because of the rapid rate of dispersal. The temperature does not pose a real problem unless some of the LNG spills directly onto a seaman or plant operator. In most cases the depressed temperature at a leak would act as a form of warning device. No significant environmental impacts are anticipated in the case of a 10 m^3 spill.

The large spill of 100,000 m of LNG which has been postulated by the Federal Power Commission (FPC) as a worst case is probably unlikely. The Coast Guard currently sees the worst case as the spill of the contents of one cryogenic tank. This would be about 33,000 m^3 in the case of the tankers proposed by EPAC.

The 100,000 m^3 spill used by FPC as the worst case is used because the model is already developed. An instantaneous release of this much LNG on the surface of the ocean would theoretically form a pool 8,500 feet in diameter with an area of 2.03 square miles if the sea was calm and the spill unconfined (Federal Power Commission, 1974).

The water column below a pool would function as a massive heat sink and the methane boiloff would be rapid. A cloud of cold vapor would form over the pool. The data developed by the Federal Power Commission indicates that it would take about 37 minutes to spread and vaporize. Another 4.3 minutes would be required for the vapor to pick up enough additional heat from the sea and the atmosphere to warm to about -190°F. At this temperature the vapor cloud would begin to achieve positive buoyancy. After that point another 2.5 minutes would be required for the gas to disperse enough that a 5% methane concentration would be reached. At that point, theoretically at least, the lower limit of flammability is reached.

At the point that neutral buoyancy is reached, 41.3 minutes after the spill, the methane cloud would be 17 feet thick and 9,500 feet across. It would be located just above the ocean surface. Forty-five minutes after the spill the methane cloud would be 650 feet thick and 760 feet above the surface of the ocean.

No one is sure that the scenario of a large spill would in any way resemble the preceding description. There is, for example, a strong body of opinion that a collision which could dump that much LNG instantaneously would create enough energy to ignite it and, therefore, preclude the formation of either a pool of LNG or a vapor cloud. The analysis of potential impacts is based on the occurrence of:

1) a fire

2) a pool of LNG, and

3) a vapor cloud.

The impacts will be instantaneous and loss of life may occur.

In order to assess the risk of casualties to people along the California shore from a large spill of LNG on water, the FPC staff has performed an analysis which indicates the risk from LNG compared to that from other involuntary risks normally encountered in daily life are comparable in magnitude to those from fire, and electrocution. These appear to be acceptable risks for LNG importation by ship.

This risk assessment is based on a model of LNG plume behavior. The model assumes that the fire hazard area for large spills of LNG on water is confined essentially to the area covered by the plume, and that when the vapor plume warms to positive buoyancy and lifts uniformly off the water the fire hazard at ground level ceases to exist. For the largest LNG spill investigated the spill would have to occur closer than 7000 feet from shore before the safety of the public ashore would be threatened by the ignitable vapor cloud.

The Point Conception Terminal and the Pipeline to Cajon and Arvin, California

Climate--The construction and operation of the pipeline and the LNG facility should have an insignificant impact upon the climatology of the region.

Wind speeds greater than 29 miles per hour occur 3.4 percent of the time at Point Conception. These occasionally strong winds could hinder LNG tanker operations. Restricted visibility due to haze and fog, especially during the months of July through October could also restrict tanker operations. Visibility is reduced to one half of a mile or less due to heavy fog 5.0 percent in October, 4.6 percent in September, 3.0 percent in August and 2.8 percent in July. Visibility reduction to 5 miles or less is at a maximum during these months also.

Topography, Geology and Soils--The proposed LNG terminal and its associated pipeline would have limited impact upon the topography and geology of the areas in which they would be located.

Impacts to the topography would be restricted essentially to areas where grading would be required. Indirect impacts would be related to increases in erosion and mass movement which could cause local terrain modifications where the surface materials are prone to landsliding.

Direct modifications to the topography would occur within the boundaries of the terminal site where grading is expected to involve 2 million cubic yards of material. The two arroyos which now drain the southern part of the site would be filled in and the eastern slope of Canada del Cojo would be significantly altered as the proposed site is brought to grade.

Changes in the erosional regime of the site would constitute the greatest potential impact of the proposed facilities on the geology and soils of the area. The breakwater and the marine trestle would alter the existing pattern of longshore sediment transport. Possible effects include increased deposition to the west of the facilities and a decrease in sediment supply to the east. This would result in erosion of beaches to the east toward Santa Barbara.

The applicant has indicated that "of the 142.3-mile corridor, 70.5 miles or approximately 50 percent is in terrain that may require ridge cuts ...." This leveling of the ridge crests would be the major direct impact of construction on the topography along the Point Conception to Arvin pipeline segment. Where such extensive terrain modification takes place the resulting disequilibrium contours could not be easily maintained. This is especially true since most of the areas which might require ridge cutting are within regions of relatively high rainfall.

Due to the low relief over most of the 109-mile segment to Cajon there should be little alteration of the topography during construction. In those areas of significant relief within the Tehachapi Mountains and near Cajon there may be some grading but the impact should be minimal.

Construction of the breakwater for the proposed small boat harbor would alter the offshore topography.

Removal of the natural vegetation at the proposed site and along the proposed pipeline route would increase the potential for erosion tremendously. Construction operations would also promote increased runoff by decreasing the surface permeability. This would result in increased erosion of areas on or adjacent to the right-of-way and plant area.

In most of the areas traversed beyond MP 100 of the Point Conception to Arvin pipeline segment and all of the Arvin to Cajon pipeline segment there would be little adverse effect in terms of increased sediment load. During the infrequent periods of sediment transport by water the sediment load is naturally high and an additional increment would probably not be critical. It should be noted, however, that erosion within the pipeline right-of-way may be serious even if the additional sediment load in adjacent streams is not a cause for concern.

Discharge of water used for hydrostatic testing could have significant erosional impact if improperly released. In addition, such discharge upon the surface within the San Joaquin Valley or the Mojave Desert could create problems with the expansive and collapsible soils of these areas.

In addition to increasing the erosion potential, construction activity impairs the productivity of soils by disturbing the normal soil horizons and decreasing permeability by compaction.

Only about 4 percent of the proposed Arvin to Cajon route is within land now being cultivated. Due to the scarcity of water over most of the route there is very little natural vegetation. The adverse impact of this localized reduction in natural and cultivated vegetation in the proposed Arvin to Cajon route should not be significant.

The proposed route between Point Conception and Arvin passes through agricultural land over 40 percent of its length. It also passes through the Los Padres National Forest. Much of this area is naturally productive and here the impact of construction would be the removal of natural vegetation along the right-of-way leaving the potential for much erosion.

The only other impact to the geology is in terms of mineral resources. The proposed pipeline would pass through unconsolidated deposits over most of its length. These are important sources of construction materials. Although construction of the proposed facilities might mean that greater care would be required during future extraction of these materials such operations would not be seriously hindered. There would be no impact upon subsurface mining or drilling from construction of the proposed facilities. Normal operation of the proposed facilities would have no impact upon the topography, geology, or soils of the area.

The geology of this region has more potential for serious impact upon the proposed facilities than vice versa. These hazards are discussed below.

Of the primary dangers due to earthquakes, 1) ground shaking and 2) ground displacement, the former is more of a problem for this proposed LNG terminal site. There are no known faults beneath the site and the maximum probable events on the Santa Ynez fault(s) would not be anticipated to result in significant (greater than 1.5 feet) displacement at the site. It should be noted that the staff has no knowledge of any detailed foundation studies for this site. Such studies, provided for other sites proposed by the applicant, are essential to the determination of subsurface structures and a complete assessment of the geological risks at any site.

The maximum bedrock acceleration at the site would be in excess of 0.7g for the maximum probable event at either of the two closest portions of the Santa Ynez fault(s). The probable events on all the other identified onshore faults should not result in site accelerations in excess of 0.2g. A San Andreas fault event would probably result in 0.1g accelerations at the site with most of the transmitted energy occurring in long period vibration. Horizontal or vertical accelerations of 0.7g could be experienced by the proposed Point Conception to Arvin pipelines at each of the 12 active or potentially active fault zones traversed.

Within the 12 zones, the proposed route crosses 19 mapped fault traces. All of these are significant hazards to the proposed pipeline. If the crossings of faults within the Garlock fault zone and the Mirage Valley fault are added, then there are 22 faults which would probably sever the proposed pipeline if the maximum probable event took place. It is not inconceivable that such events on the nearest portions of the San Andreas and White Wolf faults would cause rupture of the Arvin to Cajon pipeline. This assessment is based on the applicant's report that the proposed pipeline could accommodate displacement on the order of 1 foot in 120 feet of length.

In addition to the primary effects of earthquakes, the possible secondary effects include soil liquefaction, settlement/subsidence, mass wasting, tectonic subsidence, and tsunamis.

When a soil liquefies it loses its ability to sustain a shear stress. It acts as a liquid and consequently may flow down very slight grades. Fortunately only soils which are granular, relatively unimodal and saturated are subject to liquefaction. Such soils must be removed or avoided during construction of important facilities in highly seismic areas.

An unconsolidated soil may settle into a more compact configuration when shaken. This may result in settlement of several feet depending upon the depth of the original deposit and the severity of the shaking. Proper foundation engineering can eliminate most of the problems associated with this phenomenon.

Various mass wasting processes including rock falls, landsliding and slumping may be triggered by shaking. Problem areas are not difficult to discover and avoid after proper geological studies.

Tectonic subsidence involves the vertical motion (up or down) of large portions of the surface due to readjustment of the earth's crust during and after an earthquake. As a result of the 1964 Prince William Sound earthquake in Alaska, an area of some 100,000 square miles changed elevation by as much as 33 feet. While such events are not common, there has been a similar event in California: Owens Valley, 1872 - 20 feet or more of vertical displacement with a similar horizontal offset. Vertical movement of this magnitude may occur in earthquakes of magnitude 8 or over. However, regional elevation changes would probably have negligible impact upon the proposed facilities due to the large area involved and the frequency with which such events apparently occur in California.

Tsunamis are long period waves formed by large-scale displacements of water. These displacements are generally due to vertical motion of a portion of the sea-floor along a fault although landsliding into bodies of water may cause waves of concern to local land areas. The proposed site is not likely to be subjected to the latter type of wave.

Close to the source of an earthquake induced tsunami, the maximum wave heights are experienced along a coast which parallels the fault, while at a distance refraction of the wave front may considerably alter the direction of the wave.

Faults whose activity might trigger tsunamis near the proposed site are located in the Santa Barbara Channel. The coast at the proposed Point Conception site is parallel to the probable generating faults and would experience the maximum locally generated waves. While no adverse effects would be expected at the onshore portion of the proposed facilities, the marine terminal would be vulnerable to wave forces. Furthermore, it is unlikely that there would be enough time to warn, or remove a docked LNG tanker to a safe distance from the facilities before the wave arrived.

The major historical tsunami sources are near Chile, the Aleutian Island Arc, and Japan, although most of the rest of the Pacific Ocean border is a probable source. Houston and Garcia, 1973 have performed analyses which indicate that a recurrence interval of 500 years is associated with a wave of no more than 13 feet at Santa Barbara, while the 100-year wave is expected to be 6.2 feet or less.

The Point Conception area would be expected to be relatively sheltered from tsunamis generated in the northern Pacific, but not those coming from the southern Pacific. It is expected that, in the event of a tsunami generated outside the offshore California area, ample warning would be supplied by the U.S. Coast Guard.

Other geological hazards include floods, erosion, expansive soils, collapsing soils and volcanic activity. The proposed LNG site should not be subjected to flooding. Due to its elevation and the lack of a major drainage, the Point Conception site is extremely unlikely to be flooded.

Sheet erosion caused by storm runoff could be a problem at the proposed Point Conception site, however, proper grading and drainage of the site should be able to deal with this problem effectively.

Along the proposed pipeline route the western mountainous areas are the most likely to be affected by flooding. However, it is conceivable that this could be a problem along the entire route since flash flooding is not uncommon in the desert.

Soils containing appreciable quantities of the clay minerals kaolinite or montmorillonite are known as expansive soils. When exposed to water these soils may increase their volume substantially, moving retaining walls, lifting foundations, and adversely affecting the associated structures. Such soils must be identified and either removed or avoided.

The Montezuma clay on the southwest corner of the proposed site is expansive. Many of the soils crossed by the proposed Arvin to Cajon pipeline are highly expansive.

Collapsing soils, soils which are susceptible to hydrocompaction, are hard, dry, low density soils that compact when saturated with water. They are extremely common in the San Joaquin Valley, where they have posed severe construction problems, and probably exist in the Mojave Desert near its mountainous border.

The proposed Point Conception to Cajon pipeline crosses several areas in the San Joaquin Valley which have known problems with collapsing soils. It would be essential that the proposed pipeline be routed so that there would be no tendency for water to pond in subsidence-prone areas. Ideally this routing would be such that no natural drainage is intercepted or blocked.

There are no active volcanic centers in southern California. The last known activity occurred during Pleistocene time, but no extrusives as young as this are located within 50 miles of any of the proposed facilities. The Tertiary history of the southwestern U.S. records a steady movement of volcanic activity from west to east. Danger from volcanic activity appears to be remote at the proposed site.

Hydrology--

LNG Site and Pipeline--The gathering of site specific pipeline route information regarding shorelines, streambanks, adjacent drainage areas, and areas subject to siltation and turbidity, as well as the selection of construction techniques to be employed at the affected areas, has not been completed. Consequently, only generalized comments concerning anticipated hydrologic impacts can be made.

Construction of the proposed LNG facility could increase the sediment transported by the Canada del Cojo and, consequently, increase the amount of sediment transported to the littoral zone.

Surface water conditions in the 11 basins that would be crossed vary substantially and therefore, the effect of additional debris produced by the pipeline construction would differ from stream to stream. In tributaries where sediment transport and turbidity are naturally low, the increase in sediment load due to construction could have a significant impact.

During periods of high water, sediment added to the Sisquoc River could increase sedimentation in several gravel pit operations. Construction activity along the Cuyama River could increase sedimentation in the Twitchell Reservoir. In the coastal drainages, pipeline construction would increase the amounts of sediments transported directly to the littoral zone.

The groundwater should only be affected in areas where the local water table is near the surface. It is highly probable that excavations at stream crossings would encounter the water table very near the surface of the alluvium if construction operations were conducted during the winter. This could necessitate dewatering the construction site which in turn would result in the lowering of the local water table and temporarily altering local groundwater flow.

Water tables along the proposed pipeline route which are close to the ground surface occur in the Santa Ynez River Basin, at stream crossings in the Southern San Joaquin drainage, at MP 14.2 of the Cajon Pass leg of the proposed pipeline, between MP 1.6 and 1.8 and MP 16.3 to 16.9 of the Cajon Pass segment, and the south end of Rogers Dry Lake. In the Rogers Dry Lake area, during periods of high winter runoff, inundation of proposed pipeline route between MP 56.5 and 59.7 could occur.

Hydrostatic test water would be discharged either into catchments or into existing watershed areas and improper water disposal would result in increased erosion and sedimentation at and downstream of the discharge area.

Oceanographic Impacts--Facilities whose construction would affect the marine environment are the vaporization facilities, the pile-supported pier, a breakwater-protected small boat harbor, the intake and outfall portions of the heating water system and a screenwell.

The vaporization facility would be close enough to the shoreline so that construction wastes, spills or leaks from this portion of the project could reach the sea via the Canada del Cojo as runoff. Construction and site preparation operations associated with the vaporization facility would result in increased erosion. This could increase turbidity in nearshore coastal waters. Offshore construction would further result in temporary increases in turbidity.

Trenching or dredging would be required in the surf zone for the construction of both the seawater intake and outfall structures. This could cause disturbance of low density sediments. The proposed breakwater could affect local circulation patterns and could locally affect the littoral transport of sediment in the nearshore zone. Increases in turbidity may be the result of changes in wave refraction caused by the breakwater and marine trestle.

Discharge of freshwater used for hydrostatic testing of the LNG storage tanks and any dewatering at the plant site would produce temporary impacts resulting from salinity and temperature differentials between the effluent and the receiving water.

A tanker or barge collision or grounding in the area of the plant site could release Bunker "C" fuel oil. The adverse effects would depend on spill size, spill location, and existing meteorologic and oceanographic conditions.

Cold Water Discharge--Under base load operations, approximately 300,000 gallons per minute (gpm) of water would be circulated through the seawater vaporization system. The water temperature would be depressed 12°F in the vaporizers. Acrolein would be added in 0.4 to 0.8 parts per million (ppm) concentrations for 4 to 6 hours per day to inhibit fouling by marine animals. The cooling water would be detoxified before discharge by the addition of sodium bisulfite.

The kinds of impacts of cold water on marine organisms are dependent on the difference of temperature between the effluent and the ambient water temperature. The extent of the impact depends on the size and shape of the plume. No studies on the biological effects of cooled seawater discharges are available for comparison with the proposed system. In addition, the location and design of the outfall has not been specified. Its location relative to biotic distribution, current patterns, and natural temperature distributions would have a significant effect on the resulting impacts. Until the location and design is specified, impact assessment can only be general. Further discussion of these impacts may be found in the marine route section "Vegetation, Wildlife and Ecological Considerations."

According to Dames & Moore, the general effect of cooled water will be to force a change in the species composition of areas directly influenced by the effluent.

The "Water Quality Control Plan, Ocean Waters of California" (California Regional Water Quality Control Board, adopted July 6, 1972) is the controlling regulatory document for treatment and discharge of waste water into the marine environment along the coast of California. Treatment and discharge of effluents from the proposed LNG facilities would comply with regulations set forth in this document. Existing California Regional Water Quality Control Board regulations governing temperature differentials between the receiving water and the effluent do not apply to cold water discharges.

Vegetation--

LNG Site--Clearing, cutting, and filling activities would result in the removal of the majority of the vegetation on the proposed 227-acre LNG site. The upper third of the site and the Canada del Cojo would remain unaffected, being located outside the site fence. It is estimated that about 90 percent of vegetation to be removed on the site is herbland with the remainder mostly coastal sage scrub. The gullies on the site which contain a mixture of coastal sage and coastal bluff vegetation would be filled in. Of the 2 million cubic yards of material which would be cut from the proposed site, half would be used as fill on the site, while the other half would be disposed of at an off-site location not yet identified.

Construction of the four 10-foot diameter seawater lines would remove some coastal bluff and strand vegetation on the beach and cliffs in an estimated 100-foot wide path from the ocean to the coastal terrace above. The road from the proposed site to highway 101 near Gaviota would be widened, resulting in the clearing of an additional 26 acres of land, mainly herbland with smaller quantities of coastal sage and riparian woodland. The construction of water and electric lines leading to the proposed site would result in similar impacts.

Landscaping with trees, shrubs, and grass would offset part of the loss of primary productivity (production of plant material) on the site. The gaseous emissions from construction equipment and the proposed LNG facilities would not be in great enough concentrations to have a noticeable effect on vegetation in the vicinity of the proposed site.

Until the landscaping was completed, water runoff and erosion of the bare soil could lead to erosion of the soil beneath uncleared vegetation on the cliffs, beach, and the riparian areas.

Pipeline Routes--The construction of a 125-foot right-of-way for most of the 142.3-mile Point Conception to Arvin segment and a 100-foot right-of-way for the 108.9-mile Arvin to Cajon segment would necessitate the removal of all vegetation within these rights-of-way. Table 8.2.1-36 shows the distance in each community that would be traversed by the proposed route and Table 8.2.1-49 shows the approximate quantity of land which would be disturbed in each community. Besides the 3,400.2 acres which would be cleared as rights-of-way, 1.5 acres of herbland would be cleared for the Arvin metering station, 1.5 acres of abandoned farmland would be cleared for the Cajon metering station, and about 110 acres in undetermined areas would be cleared for temporary storage yards. Temporary dirt roads would be constructed to aid access to the proposed rights-of-way during construction, especially in the mountainous areas where there are no existing roads.

The severity of impacts to vegetational communities would depend on the time of year during construction, specific construction and revegetation techniques, community type, previous disturbance, and topography.

Table 8.2.1-49 Approximate area disturbed in each vegetational community by the proposed right-of-way, (combined values for both segments, Point Conception to Arvin, and Arvin to Cajon)

	Community	Acres	Percent of Total Acreage
	Herbland	1,333.5	39.2
Shrubland	Coastal sage scrub	187.9	5.5
	Chaparral	129.4	3.8
Woodland	Oak Woodland	181.0	5.3
	Juniper Woodland	35.2	1.0
Desert	Saltbrush scrub	298.2	8.8
	Creosote bush	341.8	10.1
	Joshua tree	26.7	0.8
	Creosote and Joshua tree	181.8	5.4
	Mesquite-alkali sink	2.4	0.1
	Cultural	677.8	19.9
	Barren	4.5	0.1
		3,400.2	100.0

Source: Federal Power Commission, 1975, Vol. III

Upon completion of construction, the proposed route would be seeded with native herbland flora.

Farmland (comprising most of the 677.8 acres of cultural land), the small quantity of barren land, and herbland would suffer the least amount of impacts with respect to vegetation. Annual crops could regrow in the proposed right-of-way the first complete growing season following completion of construction activities. The herbland in the first two biophysiographic provinces consists almost entirely of annual species of grasses and forbs which would probably revegetate during the first rainy season. A greater percentage of those forbs which grow best with little litter would appear in the right-of-way for several seasons until enough litter accumulates to favor the preconstruction mixture of grasses and forbs. The small quantities of marshland along the proposed route would take a similar duration of time to revegetate to the preconstruction state, unless drainage patterns were altered. If the latter occurred, water may be so reduced that only herbland would grow back, eliminating these valuable communities. The herbland in the vicinity of the Carrizo Plain-Temblor Range-San Joaquin Valley Province, which comprises the majority of the herbland along the route, contains a variety of small perennial shrubs along with annual herbs. The annual herbs would grow back in the manner described above, but the shrubs which dominate some areas of the herbland would take from 5 to 15 years to revegetate.

The succession in disturbed chaparral communities has been well-documented. Annual forbs which are uncommon in mature chaparral would dominate the cleared areas for the first 3 to 4 years following construction. There would be many of these species with few individuals per species at first, with several species becoming dominant. Grasses would become more common and would take over by the fifth year. If the roots of major shrub species such as chamise, scrub oak, greenbark ceanothus, and mountain mahogany are still viable, they would start sprouting from the crowns; the sprouts would keep growing until shrubs once again dominate the area within 6 to 8 years, eventually forming a climax community in around 12 to 30 years following the clearing of the lands, assuming light browsing from deer (Hanes, 1970; Sweeney, 1956; and Biswell, 1961).

However, where the root crowns have been destroyed, shrub seeds which would be in the soil following land clearing would have to germinate and eventually grow to mature plants to complete the succession. Because chaparral is a fire-adapted community, the seeds of many annuals and perennials are not only resistant to high temperatures, but actually require heat and/or scarification (rupturing of the seed coat) for optimum germination. The perennial species known to require heat include bigpod ceanothus, greenbark ceanothus, and sugar bush. The mechanical clearing may result in seed scarification thereby stimulating germination for some species. However, the lack of heat would delay the germination of other species and thus delay formation of a climax community. This would be a significant factor in chaparral in the first 45 miles of the route where the above-mentioned ceanothus species are among the dominant species. In this case, coastal sage scrub species may invade and keep out chaparral species for an indefinite amount of time.

In coastal sage scrub areas, a similar but shorter succession would take place, with an initial growth of annual herbs which dominate for several years until shrub species like California sagebrush and sage, which grow and mature faster than chaparral species, take over either from seed germination or root crown sprouting.

Well-developed oak woodland and riparian communities have a community structure similar to that of forests, with a ground layer of herbs, a shrub layer, and a tree canopy on top. Succession in these areas would consist of three stages, herbs, shrubs, and finally trees. In oak woodland, many of the shrubs, which are derived from chaparral, would form quickly as a result of sprouting from oak root crowns or stumps. It could take 100 years for a climax oak or riparian woodland to form. Oak woodland with an open canopy and no shrubs would also require as long or longer a period to completely revegetate. Coast live oak, buckeye, and sycamore are often over a century old; valley oak trees have been known to live up to 300 years (Peattie, 1953).

In juniper woodland, herbaceous growth would dominate the first several years following construction; understory shrubs, which are derived from chaparral and desert communities, would take roughly 5 to 10 years to become established. Slow growing junipers and pinyon pines would finally appear, but not be significant for at least several decades. Mature pinyons are often over 100 years old and have been known to be as old as 250 years (Peattie, 1953).

The desert communities are the most fragile of those along the proposed route. Potential impacts to the creosote bush communities have been well-documented in the article by Vasek et al. (1975) entitled "Effects of Pipeline Construction on Creosote Bush Scrub Vegetation of the Mojave Desert," which consisted of a study of a 12-year old natural gas pipeline. Where there is a fairly high vegetation production, mainly in moderately or gently sloping washes and fans, areas disturbed by construction would undergo a succession of communities leading to a climax community. Perennial herbs would come up during the first winter rains following completion of construction. Pioneer perennial shrubs which live for only several decades such as cheesebush and hop sage would quickly invade and become relatively abundant, probably within 5 to 10 years; these are normal components of slightly disturbed areas such as small washes, which are natural components of the desert. Climax species, mainly creosote bush and burrobush, would not become dominant cver the pioneers until about 30 to 40 years following construction. Mature creosote bush communities with maximum production would require one to two centuries to form. However, creosote bush communities in the proposed route which have subnormal features such as poor rocky soil and rainfall rate which is below average for the desert would not be expected to return to their preconstruction state for any discernible length of time. The pioneer species described above would probably dominate any vegetation which grows back in these subnormal areas with climax species being minor components or nonexistent. In the study, little or even no vegetation at all was found in parts of these subnormal areas after 12 years.

In the saltbush scrub and mesquite-alkali sink communities a similar pattern of succession such as in creosote bush communities would occur, but the duration of time would be lessened to around several decades for the formation of mature climax communities. The understory vegetation in Joshua tree areas would take from several decades to over a century to revegetate, depending on whether it is composed of saltbush scrub or creosote bush. Replacement of mature Joshua trees could require 200 to 300 years due to slow growth and poor seed germination (Woodward-Envicon, Inc., 1974).

In the Point Conception to Arvin segment, the proposed right-of-way follows ridges which, if too narrow, would have to be cut until sufficient construction work width is obtained. The exact ridges to be cut are unknown at this time, but they would be located in the hilly terrain between mileposts 4.5 to 18, 22 to 68, 94 to 101, and 137 to 141. During the ridge cutting process, spoil dirt would be pushed over the sides of the ridges, thus burying vegetation downhill. Most annual plants would be eliminated by burial exceeding 2 to 3 inches or by mechanical damage to the root crown.

Perennial herbs would survive deeper burial and more severe damage because they can resprout from buried parts. Coastal sage shrubs would be able to recover from burial up to about 1 foot and from severe mechanical damage. Chaparral species which can resprout, such as chamise and scrub oak, would recover from a burial of several feet, if some parts of the plant remain above the spoil or if the root crown and associated roots remain intact. Non-sprouting species could withstand burial of several feet of trunk, but would not recover from mechanical damage. Woodland trees, such as live and blue oaks, would recover from burial and mechanical damage slowly. Riparian trees are not quite as tolerant, but can recover from some burial and mechanical damage. The cleared ridges could serve as fuel or firebreaks to prevent the spread of a fire from one side of a mountain to the other. In the Los Padres National Forest, selective fuel breaks are part of an overall program to manage the forest and small portions of the clearings for the proposed route through Los Padres could be utilized as fuel breaks (Los Padres National Forest, 1975).

Probably the most significant factor which would prevent successful revegetation of the rights-of-way and cause indirect environmental impacts, is erosion. The loss of the roots, aboveground parts of plants, and surface litter which normally retard runoff and hold the soil would accelerate water erosion of the soil and loosening of rock until a plant cover is reestablished. Increased runoff would result in increased erosion of areas downhill from the cleared land and a reduction in soil fertility in both locations. Lessened fertility could result in reduced plant productivity in these areas. The runoff with its load of debris can cause increased siltation in flowing streams, as discussed in the aquatic section. Wind erosion could also be significant during periods of occasional strong winds when the soil is dry. Wind erosion is most severe in the desert, where it is more of a problem than water erosion. In addition, areas of high susceptibility to water erosion are found in about 9.7 miles of the first 61.5 miles of the Point Conception to Arvin route (the remaining part has not yet been evaluated) and about 3 miles of the Arvin to Cajon route. These areas have easily erodible substrate, thin soil, and steep slopes, where erosion could possibly remove so much soil that little vegetation could grow back.

The sections of slopes where ridges were cut as previously described would end up devoid of vegetation where the excavated material pushed over the sides was the deepest. In southern California, these newly created slopes would not be stabilized fast enough by natural vegetation. The invading vegetation would tend to consist of weak shrubs and herbs, rather than trees and woody shrubs which can form a dense canopy, strong roots and much litter to prevent soil erosion. Only reseeding and/or planting of young shrubs or trees on these slopes can stabilize the areas to insure the beginning of succession and minimize soil loss. Even with these methods, it has been shown that some erosion will take place, forming small gullies, but after about 15 years most of the once bare land on the slopes had revegetated properly. Existing roads and rights-of-way on hills in the vicinity of the proposed route have long erosion scars on the slopes beneath them where proper revegetation did not take place.

The release of hydrostatic test water has the potential for erosion. Impoundment and allowing natural seepage and evaporation, controlling flow back to the original source, or use for irrigation are the ways to minimize any harmful effects of the release of this water.

For time periods from several years up to many decades, depending on the community, constructed right-of-way and temporary access roads would be free of adequate vegetation encouraging use as a road for four-wheel drive cars or off-road vehicles. Although such usage might be illegal, it would be difficult to monitor. It would inhibit revegetation and lead to increased access to previously undisturbed areas, with resultant impacts to ecosystems there whose magnitude could not be predicted. The Mojave Desert has become the scene of the most extensive off-road vehicle activities due to the relative openness of the area and proximity to the Los Angeles metropolitan area. In localized areas, the ecosystems have been moderately to severely damaged by these vehicles and their operations, especially in the vicinity of Baldy Mesa and scattered desert buttes, and similar damages could result from usage of the proposed right-of-way (U.S. Bureau of Land Management, 1973).

The ditching and subsequent backfilling operations would result in the placement of the top layers of soil back in the ditch first with the less fertile layers on top. As a result, overall soil fertility would be reduced for two strips of land 4-1/2 feet wide and 142.3 miles long for the two parallel pipelines from Point Conception to Arvin. An additional strip of land 4-1/2 feet wide and 108.9 miles long from Arvin to Cajon would also be affected. This reduction in fertility is evident in crops growing above trenches in existing rights-of-way through agricultural areas; the crops tend to be somewhat smaller above the trench than those along side it.

Construction would take place over a period of at least 12 months, rather than limited to a specific time of year. In the fire-sensitive communities, the danger of fires would be greatest in the dry season from about June through September. These communities, chaparral and associated coastal sage scrub and oak woodland, occur mainly in the Transverse Ranges Province (first 45 miles of the first segment; last 4.9 miles of the last segment) and the Southern Interior Coast Ranges Province (mileposts 45 to 65 of the first segment). Herbland is less susceptible to fire due to smaller accumulation of litter than in the shrubland and woodland communities. The desert communities could be cleared and trenched during any season without concern for fire since there is virtually no litter and the plants are spread out from one another. Construction during the rainy season which occurs in all provinces except for the Mojave Desert would however increase the severity of water erosion in the cleared areas.

Rare and Endangered Flora--There are 26 species of rare and endangered plant species which could be found along the proposed route. The occurrence of these species within the proposed right-of-way and other areas to be cleared is not known, but colonies of some of them would be expected to be encountered. It is doubtful if construction would result in the extinction of any of these species since many would occur across regional and local size areas larger than the disturbed corridor and some probably reseed themselves. The annuals would be expected to be least affected by construction. As discussed in the "Existing Environment" section, annuals are pioneer species whose abundance is stimulated by disturbance. However, disturbance of soil profiles could prevent the reestablishment of those species which have very specific soil requirements, mainly the rare and endangered plants: Scrophularia atrata; Carex obispoensis; Monardella palmeri; Hemizonia arida; and Puccinellia parishii.

Wildlife--

LNG Terminal Site--The removal of most of the vegetation from the proposed site, and an additional 26 acres for road improvement would displace fauna through habitat destruction for as long as buildings, tanks, roads, and equipment occupy the site. This would have an overall effect of slightly lowering the wildlife carrying capacity of the general area for the life of the project. The road would probably become a permanent fixture in the area and thus would represent a permanent loss of habitat. The disposal of the 1 million cubic yards of excess material cut from the proposed site would result in the destruction of additional wildlife habitat if placed on land in a natural state. The introduction of trees onto the proposed site due to the planned landscaping would improve the wildlife variety on the site by providing habitat for tree-dwelling birds and mammals.

Short-term impacts from noise and dust during construction would scare away wildlife from the general vicinity of the proposed LNG site. Since construction of the LNG facilities would take over 3 years, those individuals scared away would probably migrate to similar habitats off the site. Their survival off the site would depend on the availability of suitable habitat and the carrying capacity in those habitats at the time of construction. Assuming the populations of animals in the Point Conception area are at the normal carrying capacities, some displaced wildlife could find other suitable habitats to feed and rest in. Birds would not be able to establish breeding territories. The number of these territories remains at a much more constant level than the overall number of individuals of a species; there are always "extra" individuals which do not breed. The green heron, black-crowned night heron, belted kingfisher, and band-tailed pigeon would have the most difficult time of all species in finding new habitat. These are confined to the riparian community around Canada del Cojo. Riparian communities occur only intermittently in the Point Conception area and vacant habitat for these birds probably is rare or non-existent.

The operation of the proposed facility would increase the noise levels in the project area. Although not yet measured, present levels are probably in the vicinity of 30 dB(A), typical of a natural community with no human disturbance. Expected operational levels on the property boundaries would be in the range of 60 to 65 dB(A), equivalent to the noise produced by slow-moving cars heard immediately adjacent to the road. At 1,000 feet from the boundaries, the levels would be in the range of 50 to 55 dB(A), equivalent to light auto traffic at 50 feet. During normal operations noise would be emitted at a relatively constant rate for the life of the project. Unfortunately, little information is available concerning the effects on animals from the type of sound emitted by the proposed facilities. This noise source could generally be called constant and would not result in intense or impact type noise levels at the property boundaries. One general conclusion that can be drawn is that most animals would initially avoid areas around the proposed site due to increased noise levels, but would adapt to these levels and possibly repopulate the area.

One study with Japanese quail (U.S. Environmental Protection Agency, 1971) showed that males separated from females increase the frequency of calls to their mates when there is an increase in noise levels similar to the increase expected due to the proposed project. This is an example of one species' response and adaptation to the masking effect of noise. This might be expected of other bird species--as noise increases, individuals wishing to verbally contact others would call more often or louder.

Pipeline Routes--

1. Birds and Mammals. The major impacts on animals due to construction of the proposed rights-of-way would consist of loss of habitat, destruction of food sources, death to those animals which are unable to escape from construction equipment, and disturbance to breeding animals. Following construction, use of the proposed rights-of-way by off-road vehicles would represent a long-term impact.

During construction activities, most animals would vacate the area near construction due to the increase in local noise and dust levels. Following completion of construction, most animal life would return to the area adjacent to the cleared rights-of-way and access roads. However, as discussed in the rare and endangered section, many large raptors are extremely sensitive to noise and abandon their nests when disturbed by blasting or traffic during the breeding season. Due to the small amount of time required to construct any portion of the pipeline and the moderate increase in sound during that period, no long-term adverse effects from noise would be anticipated for any animals, wild or domestic, which do not vacate an area during pipeline construction.

Invertebrate fauna living under or on the surface would suffer the greatest impacts from trenching and clearing. With the exception of adult insects, they lack comparatively fast movement and would be unable to escape the disruption of the ground by clearing or trenching. These species would not suffer any long-term impacts due to their abundance and large reproductive potential.

Construction activities, especially trenching, would destroy small hibernating animals such as amphibians located within the proposed rights-of-way. Animals which sleep or rest in burrows such as small rodents, lizards, the desert tortoise, foxes, and badgers, would either be killed or forced to seek out suitable habitat in areas adjacent to the proposed rights-of-way or access roads.

Most rodents have relatively small territories, generally less than an acre (Macmillen, 1964). Most passerine birds in shrubland and woodland also have small territories. The impact on these animals would be severe as they would be forced to seek new territories due to the loss of habitat when vegetation is removed. The success that they would have in relocating would depend on the availability of suitable habitat and the carrying capacity of the area at the time of construction. As stated in the previous section, the populations of species in the areas adjacent to the cleared rights-of-way and access roads could increase slightly above the carrying capacity at that time to absorb some of those wildlife displaced by construction. Bird species absorbed into these areas would be able to feed and rest, but would not be able to establish breeding territories. Animal species not absorbed into new areas would perish.

The loss of habitat for all wildlife species would be most significant in areas where the particular habitat for certain species is extremely limited. In the Carrizo Plain-Temblor Range-San Joaquin Valley and the Tehachapi Mountains Provinces, riparian, juniper, and oak woodland occur in scattered separated areas, providing the only significant cover and breeding areas for wildlife species for many miles. These species include mammals such as skunks, mule deer, the pinyon mouse, Merriam chipmunk, and raccoon; and birds such as owls, hawks, the plain titmouse, and pinyon jay; most individuals of these species would probably not be able to find vacant habitat.

As the populations of tree-dwelling species such as the western tree squirrel and various woodpeckers are reduced when trees are cleared from the land and the populations of species more adapted to open areas would increase. Among rodents, the clearing of vegetation in shrubland and oak woodland would create opened areas more favorable to the California meadow mouse, a species confined to herbland. It would replace such common species confined to shrubland and woodland, such as the California pocket mouse, brush mouse, and California mouse until sufficient revegetation of shrubs and trees takes place.

Clearing of vegetation in areas of shrubland and oak woodland could temporarily increase the populations of many wildlife species in these areas until the shrubs grow back again to their preconstruction size. The sprouts from still live root crowns of shrubs and the large quantity of herbs which are found several years after clearing are very valuable as food for wildlife. Deer, jackrabbits, quail, and mourning doves have been observed to have increased populations following the clearing of shrubs (Biswell, 1961). These are species which prefer opened areas of brush, as opposed to solid closed shrubland.

No adverse effects on deer migration would be anticipated because mule deer along the proposed route do not form migratory herds. Game trails for a variety of species would be disrupted, but could be reestablished by the animals.

Water catchments for wildlife use may exist along the proposed route in both the Los Padres National Forest and the Temblor National Cooperative Land and Wildlife Management area. The disruption by construction activities of natural water sources such as Buck Cove Spring and Clifford Spring could permanently reduce populations of deer and grain-eating birds such as California quail and mourning dove. The destruction or draining of any pools or marshes would result in the destruction of the populations of amphibians inhabiting them.

The proposed rights-of-way and any associated access roads could be utilized by off-road vehicles. They would scare away wildlife in the general area near the rights-of-way and access roads, and would permanently reduce the carrying capacity for various species by preventing revegetation along these corridors. A 50 percent reduction in deer numbers has been noted in a one quarter mile wide corridor on each side of back-country roads in the states of Washington and Colorado (U.S. Department of the Interior, 1975); similar results would be expected due to construction of the proposed project. Many vehicles would be capable of traveling off the corridors, creating direct impacts themselves and leading to the formations of new vehicle trails. Where these vehicles would pass adjacent to water sources, some animals could be forced to find alternate sources. Inspection of the finished pipeline several times a year by land vehicles would also result in scaring away wildlife.

A total of 3,400 acres would be required for the proposed rights-of-way. However, this quantity does not represent the total wildlife habitat which would be disrupted. The construction of access roads and the pushing of spoil dirt onto slopes below ridges which are cut would add an undeterminable acreage to this figure, as would the creation of any new trails from off-road vehicles. Erosion from the cleared areas on slopes below these areas and any increase in fires would also increase the total acreage disrupted.

2. Freshwater Species. The effects of construction on the aquatic habitat would arise primarily from stream and river crossing and surface runoff from cleared areas. These effects would be temporary, and would be restricted to relatively small, downstream portions of the waterways so that overall these areas should not be greated affected.

The two major results of construction activity would consist of siltation and the release of chemicals previously bound in the soil. The general effect of siltation on the aquatic environment is to severely reduce both the kinds of organisms present and their population numbers.

As particulate matter settles to the stream bottom it creates undesirable physical environments for the organisms normally present. These undesirable areas are created by the screening out of sunlight, changing of heat radiation, formation of a silt layer on the stream bottom, and release or introduction of organic materials or other substances, such as heavy metals, that may create toxic conditions. Eggs and larval stages of various organisms could be smothered; fish feeding would be hampered and spawning areas could be lost. Accumulation of sediment would cut off oxygen and food supplies to benthic organisms, and small pools used for breeding by certain aquatic organisms would be filled in and lost.

Marine Biota--The proposed facilities that would involve construction and operation related impacts on the marine environment include the 4,600-foot long pile supported trestle and pier terminating in a water depth of 60 feet (above MLLW); a break-water-protected harbor for small boats, which would be located on the east side of the pier in approximately 20 feet (MLLW) of water; the intake and outfall structures for the heating seawater system; and a screenwell and fish return system.

1. Impacts from Construction Activities. The small boat harbor would consist of a rock breakwater which would be connected to the trestle via a roadway on top of the breakwater. The "U" configuration of the breakwater would be approximately 1,000 feet long. The boat harbor would be used as a construction dock during the LNG terminal construction phases. During plant operations, the harbor would shelter tugs, barges and other small craft. The height of the breakwater would be determined after meteorological and oceanographical study of the site has been conducted. The appropriate type of breakwater to be built at the site would be determined following model and resource studies. Regardless of the type of breakwater, floating marine construction equipment would be required. Hauling barges would transport the materials to the site and floating barge cranes would be used to place the materials.

Emplacement of the breakwater would cause an almost complete mortality of the slow-moving and sessile organisms, the infauna (organisms living in the substrate), and the benthic plants which are present at the site. The more abundant invertebrates in the immediate area which probably would not survive the breakwater construction include abalone, hydroids, anemones, and several species of starfish. Less common invertebrates include sea urchins, rock crabs, and lobster. The area is on the nearshore edge of the kelp beds. Characteristic algae in this transition zone which would be destroyed include Macrocystis (giant kelp), Egregia (feather boa kelp), and possibly some Pterogophora (a brown algae).

Sediments suspended as a result of rock placement activities could have several detrimental impacts on organisms in the area immediately adjacent to the activity. Suspended particles can clog the filter feeding and respiratory mechanisms of many animals. Their eventual death can result from simple abrasion from sand particles. As the particles settle out of suspension, benthic organisms may be buried. The motile organisms such as fish would move from the construction area and avoid serious damage. Some of the sedentary or slow benthic organisms are adapted to shifts in seafloor materials, but their survival would depend on their mobility, and the rate and volume of settling material. With increasing distance from the breakwater, the possible effects described above would diminish. Until more adequate information is supplied about the proposed structure and the physical oceanography, further assessment or quantification of construction impacts from the breakwater emplacement will not be possible.

The impacts associated with installing the trestle pilings would be similar to those described above for the breakwater placement. The area of impact involved under each of the piles would be considerably less; however, due to the linear extent of the trestle, more habitat types and associated biological communities would be impacted. It is expected that the impacting of several small areas over the length of the trestle would not, in itself, constitute a significant threat to the populations of plants and animals in the vicinity of construction activities.

Boat and barge activities during construction would cause the loss of the kelp canopy in the vicinity of the breakwater and pier installations. The physical cutting of the kelp fronds would decrease primary productivity in the immediate area. However, the loss of kelp production may not be significant because frond regeneration is rapid and because increased light penetration would allow increased phytoplanktonic production. Nutrients released from sediment disruption may, given sufficient oxygen, further increase primary production. In any case, the net short-term productivity change should not be significant.

Sufficient information on the design, location, and construction procedures aspects of the seawater intake-outfall system and the screenwell are not available to accurately assess the impacts which would be associated with this aspect of the proposed construction. However, it is assumed that dredging would be required in the surf zone in order to construct the intake and outfall structures. If dredging is required habitats and organisms in the vicinity of the dredging operations would be destroyed. In addition, impacts from sediment movement and increased turbidity would be similar to those discussed in relation to the breakwater construction. Because the dredging would be in the surf zone, the organisms affected would include intertidal flora and fauna as opposed to neritic organisms. The significance of the impacts from constructing the intake-outfall structures is not known. Any speculation on the significance of such impacts would be unfounded without more information on the structure design and construction procedures.

Freshwater used for the hydrostatic testing of the LNG tanks and any water collected from dewatering at the plant site would be discharged into the marine environment. About 11.5 million gallons of test water would be required for each tank. If scheduling permits, the same water would be used to test all tanks. Measures must be taken to minimize the adverse effects on the marine environment.

The discharge of at least 11.5 million gallons of water into the sea could reduce the salinity of the ocean water in the immediate vicinity of the discharge. The amount of salinity reduction and the size of the area affected would depend on the rate of discharge, the water current patterns, and the ultimate volume discharged. The impacts on the physical environment, such as habitat destruction, would depend on the discharge techniques used. The impacts on the marine biota would also depend on the discharge techniques and on the organisms located in the area of reduced salinity. Some organisms can move from the area. Others can close themselves off from their surroundings and thereby avoid temporarily the lower salinities. Some organisms can tolerate lower salinities for short durations while others cannot.

2. Recovery from Construction Impacts. The breakwater structures would be installed early enough in the construction phases to allow the boat harbor to be used as a construction dock. During the lag between completion of the breakwater structures and startup of plant operation, the areas impacted by the breakwater construction would partially recover. A period

of 2 to 5 years may be required before a biologically recovered (breeding) community would be established. The breakwater structure would be a high-relief object, as would the trestle pilings, and would be able to support a greater abundance and diversity of organisms than in low-relief or sandy areas.

The breakwater area would indirectly create a relatively low energy environment within the berthing area as a result of changes in wave and current movement. Therefore, the creation of this breakwater habitat should lead to the development of a biotic assemblage characteristic of southern California's protected, rocky areas. On the seaward side of the breakwater, biotic communities typical of high-energy rocky areas should develop. However, should the cold water plume from the seawater outfall encroach on the breakwater, the communities developing on the breakwater could change. See the discussion of the cold water plume for additional information.

3. Impacts from LNG Terminal Operation. Under base load operations, approximately 300,000 gpm of seawater would be circulated through the vaporization system. A screenwell and fish return system would prevent the passage of larger organisms and debris through the system. Most adult fish (depending on the screen mesh size) would be diverted through the fish return system. A biocide, acrolein, would be added to the seawater intake at an average rate of 0.6 parts per million (ppm) for 4 to 6 hours per day to inhibit fouling of the system by marine organisms. The acrolein would be neutralized by a stoichiometric quantity of sodium bisulfite prior to discharge. These chemicals would affect some biota locally.

The entrainment system consists of a screenwell inside of the intake pipe, a trash rack, and traveling screens. The initial entrainment of organisms would kill most and stun some of the larger organisms. Those few larger organisms which survive through the system could return to the sea through the screen wash system which would discharge into the surf zone. However, most of the organisms which are trapped by the screens and pass through the fish return system would probably be injured. These organisms would not be expected to survive because they would be easy prey, and injured organisms often succumb to diseases. Even a surficial scratch can prove fatal through disease. Water velocities at the intake to the traveling screens should be kept low to minimize damage to large marine life.

It is anticipated that plankton, fish eggs, and larvae which pass through the vaporizers will be destroyed. The temperature shock and mechanical abrasion alone would probably be sufficient to kill many species of plankton and the intermittent addition of acrolein into the heating water would kill the remaining organisms prior to adding the sodium bisulfite as a neutralizer.

Due to the intermittent addition and neutralization of the acrolein, no significant effects of the biocide should occur in the open sea during normal operations of the plant. A system to stop and neutralize the acrolein input in the event of failure of the neutralizer addition system would be provided.

If accidentally spilled, the acrolein could enter the marine system and kill organisms in the area. The damage from such an accident would depend on the amount of acrolein spilled, location of the spill, and the effectiveness of emergency cleanup and neutralization procedures. Data from the producers of the neutralizing agent, sodium bisulfite, indicates that this solution, normally 35 percent by weight, has a pH of 4.0. Direct contact with sodium bisulfite would cause discomfort and burns in both humans and marine organisms.

If fuel gas firing is used, 15 gallons per minute of acidic (pH 5.5), freshwater overflow would be generated. It would be diluted and discharged through the 300,000-gpm seawater discharge pipelines. The desalination unit would produce 235 gpm of high salinity (about 1.1 times ambient salinity) return water and an average of 0.5 gpm of blowdown water from the boilers used in the flash distillation unit. Storm runoff from the process area is expected to average 135 gpm.

If contaminated with oil, drainage from the diked oil storage areas would be processed to remove the oil before being added to the holding pond. A small volume (not to exceed 5 gpm) of fresh cooling water from the utility and instrument air compressors may periodically be added to the holding tank. An average of 7.3 gpm of sanitary waste water from the combination of raw sewage and oil-contaminated drainage, which has been processed through activated sludge treatment and a chlorinater, would also be added to the holding pond. These discharges may be combined with the heating water return system or discharged directly into the ocean. No adverse effects would be expected to result from these minor additions.

When fuel firing is required, freshwater would be used in the heat exchange system. The volume of this water has not been specified. On return to base load operations, this freshwater may be stored, discharged into the holding pond, or added to the heating water discharge. Until the volume and means of discharge are specified, however, the potential impact of this waste water cannot be assessed.

Relatively insignificant losses of surface kelp would result from LNG ship and small-craft operations. With the head of the pier in 60 feet of water, the outer edge of the existing kelp canopy would be inshore of any normal LNG ship operations. Since the small boat harbor is within the kelp zone, some losses of surface kelp would be expected as a result of barge and tugboat activities.

LNG tankers are constant draft ships. To maintain proper trim, an equivalent weight of seawater must be taken on board for each increment of LNG discharged at the terminal facilities. This process would be reversed at the LNG onloading facilities in Alaska where ballast water would be discharged as LNG is loaded. Ballast water may serve as a medium of transport for southern California planktonic marine organisms to the Alaskan LNG loading sites. Impact of ballast water uptake at the marine facilities is limited to the removal of plankton contained in the ballast water.

Diesel fuel and Bunker "C" fuel oil would be shipped by barge to the proposed site. Bunker "C" fuel oil would be onloaded to the LNG ships at the LNG unloading platform. The effects of oil spills on marine biota are varied and dependent on a number of parameters, including size of spill, type of oil, length of exposure time, oceanographic and meteorological conditions, and cleanup and containment operations.

Impacts can be decreased by effective operational procedures and containment and removal of any spilled oil. Cleanup or oil spill containment contingency plans would be developed for this site. Because of the lack of extensive rocky intertidal areas within the immediate site it is expected that damage to the biota of this area would be minimal. However, damage could be severe to biota which develops on the breakwater areas, as well as to the surface feeding marine birds known to occur in the site area.

Rare, Endangered, or Protected Species--Impacts on rare, endangered, or protected species have the potential of being much more severe than those on common species. The elimination of only a few individuals of a rare population could tilt the balance toward extinction of that species.

The proposed route would involve construction through roughly 47 miles of habitat for the San Joaquin kit fox. With a 125-foot right-of-way to be cleared along this segment, a total of about 1.1 square miles of fox habitat would be destroyed. This represents about 0.03 percent of the remaining fox habitat, or a reduction in carrying capacity for one fox, based on a maximum population density of one per square mile (Laughrin, 1970). Successful revegetation would make this a temporary impact lasting up to 15 years. Construction activities, especially trenching, could destroy kit foxes if inhabited dens are encountered. The abundance of vacant dens (Morell, 1972) indicates that capturing and relocating foxes to prevent destruction from pipeline construction could be successful and may be essential.

No known Mojave ground squirrel population would be encountered by the proposed route, but it is possible that some presently unknown populations could be crossed. A small quantity of potential habitat in the desert would be destroyed. Based on its food requirements of plants such as cactus, saltgrass, Russian thistle, and saltbush (Martin et al., 1951), any reduction in carrying capacity should last no longer than a decade. Dormant species could be destroyed in their dens during the estivating period from August to March. This could be significant due to the limited number of these squirrels.

The ringtail would have a slightly reduced carrying capacity due to habitat destruction in various areas along the proposed route. Construction could kill some animals sleeping in dens during the day. These impacts are not significant because the ringtail is widespread, though uncommon, and not at all in danger of extinction.

No impacts are anticipated on the California least tern and California brown pelican because no nesting colonies would be affected by construction or operation. The pelican would not be able to utilize the strand area of the proposed LNG site for resting while construction on the strand takes place, but would probably utilize nearby beaches until completion of construction.

Construction through herbland and small marshland areas of the San Joaquin Valley would further limit declining winter habitat of the sandhill crane in California, although no large marshes would be affected.

No impacts on the California condor would be anticipated due to the distance from the nearest nesting site and feeding area. The Sisquoq Condor Sanctuary is about 15 miles south of the proposed route. Use of any access roads which would be constructed by off-road vehicles and subsequent human intrusion could bring activities nearer to the nesting site, but probably not close enough to cause nesting failure.

The American peregrine falcon would not be expected to be adversely affected by construction because of the lack of any nesting sites near any of the proposed facilities. Destruction of foraging habitat would occur, but would not be significant due to the wide range of this species.

Impacts could be severe to the prairie falcon if nesting sites were encountered during rights-of-way and access road construction. These activities would cause nesting failure of any nearby falcon pairs. Off-road vehicle use on the proposed rights-of-way and access roads would cause nesting failure by falcons nesting near these areas. Due to the potential long-term nature of off-road vehicle use, this represents a more severe adverse impact than the pipeline construction.

No known southern bald eagle nesting sites occur in southern California, therefore, no adverse impacts on this species are anticipated. Construction could benefit this species by creating cleared areas in and along the borders where small rodents could be more accessible to these predators.

Impacts to the white-tailed kite should not be significant. Cleared rights-of-way through woodland and shrubland would open up additional feeding areas but some nests could be destroyed.

Construction would occur in several areas near known populations of the blunt-nosed leopard lizard. Impacts could be severe if lizards resting in their burrows were destroyed by trenching or clearing activities. Carrying capacity would be reduced until revegetation has occurred.

The desert tortoise is not as rare as the blunt-nosed leopard lizard. The destruction of shallow burrows used as nesting sites by this species could have an adverse impact upon the desert tortoise.

The Tehachapi slender salamander would probably not be harmed because its nearest occurrence is 5 miles from the proposed route. However, significant impacts could occur if new populations are discovered within the proposed right-of-way.

The three protected amphibians (southwestern toad, red-legged frog, and ensatina) are prevalent enough in California that construction would not endanger these species, although habitat and/or individuals may be destroyed.

Ecological Considerations--Plants, animals, and the non-living parts of the environment all interact to form an ecosystem where energy is transferred back and forth. Plants are eaten by animals which are eaten by other animals, which in turn die and decay to provide nutrients for plants. These relationships form a food web. The more stable an ecosystem the more resilient it is to outside changes. Ecosystems in areas of extreme climate such as the Mojave Desert have the least ability to absorb impacts. The destruction of plants by the various construction activities could disrupt the food chain and reduce the carrying capacity for the animal community.

With respect to disruption of natural ecosystems, the sum of all human actions or projects must be examined. A project such as the proposed Point Conception to Cajon pipelines could destroy small populations of rare plant or animal species or unusual ecosystems, and would lower productivity of a variety of local ecosystems. These impacts represent an individual project. However, their true significance lies in the fact that they are only a portion of the synergistic effects of many unrelated projects, which over a long period of time can have a far more significant combined impact on the environment. For example, the gradual loss of natural communities would not only lead to extinction of rare animals, but would make animal species now common, rare or extinct in the future. Rights-of-way occupy a considerable quantity of land. As of 1958, rights-of-way in the United States, for various utilities, comprised an area greater than that of the six New England states combined (Egler, 1958). In 1970, there were more than 1 million miles of natural gas pipeline alone whose rights-of-way occupied nearly 4 million acres. It is estimated that by 1990, there will be over 18 million acres of gas rights-of-way. The magnitude of these figures indicates that the selection of the most environmentally sound right-of-way routes, elimination of others by utilizing existing routes, and the adaptation of various mitigating measures by private industry and government agencies could significantly reduce the general trend in this country of lessened primary productivity, animal populations, community stability, and species variety.

Socioeconomic Impacts--

Construction of LNG Facilities--The local socioeconomic structure of Santa Barbara County would be significantly affected by several immediate and long-term impacts as a result of construction and operation of the proposed LNG facilities near Point Conception. The construction phase of the project would result in impacts which would place temporary demands on local housing, the local work force, construction contractors and suppliers, and related services. Long-term effects would be placed on housing, social and protective services, and potential industrial development as a result of operation of the proposed facilities.

During construction, the availability of housing facilities for the influx of workers would be the most immediate problem. It is anticipated that approximately 80 percent or 1,500 workers of the total peak period work force (1,800 workers) would come from the Santa Barbara County labor pool. Housing impacts could be substantial if enough workers are forced to relocate for the duration of the construction period. Many employees may commute from their homes on a daily basis but others may relocate in temporary housing closer to the construction site. Those workers brought in from adjoining counties would probably maintain their distant residences and would commute on a weekly basis. They may choose to reside in local rental accommodations during the work week. Others brought in from outside the southern California area or those who would be associated with the project for a longer period of time would probably relocate their families into the regional area. Those who relocated would make use of rental accommodations or purchase permanent-type housing.

The magnitude of impact on available housing in the county would depend on where and when the demands would be placed. The larger communities of Goleta, Santa Barbara, Lompoc, and Santa Maria would usually have more housing available than the smaller communities such as Buellton, Solvang, and Santa Ynez. Accommodations become scarce and rates high with the influx of tourists during the summer season. The tourists are mainly concentrated in the Santa Barbara area. This situation may force workers to seek accommodations in the northern county motels, which may increase daily commuting distances and highway traffic.

The availability of rental housing units and trailer and camper parks is very low within the area. In 1970, the U.S. Census estimated that 2,175 vacant housing units were for rent in the county. This represented less than 2.5 percent of the total existing units. Vacant housing for sale is even more scarce.

It is anticipated that housing will be difficult to obtain. The current lack of camper and trailer courts may result in pressures to develop new facilities or expand existing units. Despite the potential problems, impacts incurred on housing during the 3-year construction period would for the most part be temporary.

For the duration of construction (approximately 39 months) the expected increase in population as a result of pipeline construction is expected to be relatively small. However, urban services such as police and fire services, schools, hospitals, and public utilities would be affected to some degree by an increased burden.

Should the proposed project lead to the development of new residences and businesses, police and fire protection would be expected to expand. Law enforcement would be needed in areas where transient housing was erected, and an increase in traffic controls would be required, particularly along U.S. Highway 101.

Should local law enforcement and fire protection services be inadequate, these departments would incur additional expenses to provide extra temporary support. However, these expenses may be offset by substantial tax revenues generated by construction activities to the county and other governmental recipients.

Since a majority of the workers will already be residents of the county area, the influx of new students would probably be minimal. However, if 300 highly skilled workers and families were brought into the area during the construction period of the LNG terminal, it is possible that up to 600 new students could be added to the local school system. If these workers decided to reside in the towns nearest the proposed site, it is possible that some overcrowding in the schools could occur. Accessible hospital services in the cities of Lompoc, Solvang, Goleta, and Santa Barbara should be able to accommodate any required emergency service.

The purchase of necessary construction materials would be obtained from the nearest available source. The purchase of materials such as sand, gravel, and sandstone within Santa Barbara County would be an economic benefit to the local suppliers. Structural steel would be imported. The importation of construction materials by rail service would be an economic benefit to Southern Pacific Railroad. However, any rail traffic disruption caused by construction of the proposed railroad spur and trestle which would span the existing track, could upset existing rail service. The railroads would be expected to take necessary steps to minimize inconvenience to their customers during these periods of interruption.

The expenditure of payroll money on large supplies of food and other necessary supplies would be a significant economic benefit to retail and wholesale establishments, but would be limited to the duration of the construction phase. The total construction payroll is estimated at $96 million of which $73 million in disposable income would be made available. Approximately $61.3 million would be available to Santa Barbara County's economy over a 3-year period.

Expected sales tax revenue on the taxable portion of the disposable expenditures (approximately $34 million) is estimated at $2.04 million. A 1 percent revenue charge by the taxing cities and Santa Barbara County would gain $340,000 while the State of California would gain $1.7 million from a 5 percent sales tax revenue.

Building permit and plan-check fees which would be paid to Santa Barbara County would be based upon the value of construction and would represent approximately $905,000 in revenue.

Water which would be needed during the initial phases of construction would be transported to the construction site and stored. All storage tanks would be removed upon completion of the project. Electric power would be provided by either temporary fuel-powered generators located on the construction site or brought in on temporary connecting lines via Gaviota. Sanitary facilities would consist of portable chemical toilets and would be removed upon completion of the project.

Although public access by road is forbidden by the property owners of Hollister Ranch, a significant number of people use the beach and offshore resources for commercial and recreational use. Construction activities could cause minor economic losses in commercial fishing and kelp harvesting as boats would have to avoid the immediate construction area. Such activities would produce noise and disruption of the water which may possibly result in smaller fish catches or would create an increased expenditure in time and fuel in order to fish elsewhere. Recreational boaters and surfers would have to avoid the construction area as well, thereby limiting recreational use near the Point Conception area.

Onshore, grazing activities would have to be terminated near the construction areas. This may result in minor economic loss. No field crops would be affected.

Due to the remote location, the site has limited exposure to the general public but the presence of the facilities would significantly alter the visual aesthetic nature of the local area. For many years, the unchanged pastoral character of the area has been preserved. The introduction of a major industrial LNG facility would drastically alter this existing state. Not only would the site facilities be visible from the Hollister Ranch area but the many commercial and recreational boaters who use the area would be subjected to the visual impact of the onshore and marine facilities. Traffic congestion and dust would be generated and would be visually disruptive elements to the residents of the Hollister Ranch and to the people using the Gaviota State Beach Park access road.

Operation of LNG Facilities--Operation of the proposed LNG facility would require an estimated operating staff of 80 persons who would be receiving a gross annual payroll of approximately $1.415 million. This gross annual payroll would contribute approximately $1.08 million in disposable income per year within Santa Barbara County, since it is expected that all the personnel employed in operating and maintaining the facilities would be permanent residents of the county. Over a 20-year economic life period, approximately $21.6 million would be contributed to the economic base of the county.

It is anticipated that the majority of the operating personnel would be recruited from Santa Barbara County, but some employees may be drawn from neighboring counties. Population growth within the county, related to the operation of this project, is expected to be minimal. The potential impact on the available housing supply should also be minimal.

Urban services such as police and fire protection would have to be expanded to the extent that any new residences associated with employed personnel would have to be protected. This should not be significant. While costs for additional protective services would increase, public revenue from the LNG facility property taxes would compensate for any increased expenditures.

The electric power requirements of the LNG facility would be quite extensive and would necessitate the expansion of the Goleta substation and transmission lines to the project site. However, SCE would not have to increase their generating capacity. The proposed 66 kv transmission line would extend for 35 miles from Goleta and would require a right-of-way 150 feet wide. Up to one-half acre of land would be required for the expansion of the Goleta substation. The estimated cost for these new electrical facilities is between $3 million and $5 million.

Water and sewage requirements would be met by onsite facilities. The proposed desalinization plant should provide adequate freshwater to meet the estimated needs. An onsite sewage treatment plant would handle the estimated 4,900 gallons per day of sanitary wastes.

Upon completion of construction, the total estimated value of the facility (excluding interest during construction) would be $301.4 million. The ad valorem (property) taxes on the completed facility should add $6.7 million annually to the revenue of the county, districts, and agencies sharing the tax dollar. The accrued property taxes would account for the principal beneficial economic impact upon the county.

Operation of the facility would require no relocation of residences or businesses. Access to the beach areas is presently restricted along the privately-owned road from Gaviota. There is no public area along the entire road and consequently beach use is low.

Construction of Pipelines--Construction of the proposed gas pipelines from Point Conception to Arvin and from Arvin to Cajon would have several immediate short-term impacts on the socioeconomic structure of the counties which would be traversed.

However, one significant long-term impact would be the restriction upon building any permanent structures within the rights-of-way corridors. Construction activities would cause short-term, minor economic losses in agricultural areas. Grazing activities which would be disrupted would have to be relocated or terminated, which could involve some economic cost. Crop cultivation schedules would be similarly disrupted. Upon completion of the construction phase, land previously used for agriculture would be restored to its original use and appearance. However, the rights-of-way in forested areas, particularly in Los Padres and San Bernardino National Forests, would be kept clear.

The pipeline routes which have been selected would avoid residential and commercial areas and would not result in any displacements or relocations of families or businesses. For the Point Conception to Arvin segment of pipeline, approximately 114.5 miles of private land and 27.8 miles of Federal land would be traversed. The Arvin to Cajon segment would require crossing approximately 85.7 miles of private land and 23.2 miles of Federal land.

The 108.9-mile Arvin to Cajon segment of the pipeline, would require an estimated peak work force of 225 craft and direct supervisory personnel. The majority of these construction laborers would be hired from the existing labor pools in Kern and San Bernardino Counties, and particularly from Los Angeles County. However, certain highly specialized personnel, such as construction supervisors, inspectors, welders, and side boom operators, would be drawn from statewide or national pipeline construction labor pools. Western estimates that for the Arvin to Cajon segment, 75 percent (170 workers) would be drawn from the county labor pools while the remaining 25 percent (55 workers) would be recruited from more distant areas. It is expected that most of the construction workers for the Point Conception to Arvin segment of pipeline would be drawn from the existing labor pools in Santa Barbara, San Luis Obispo, and Kern Counties. Assuming that 75 percent of the construction laborers could be supplied from the county labor pools, this would yield 525 workers from the regional area. Approximately 175 workers may be recruited from more distant areas.

The pipeline construction phase for both segments of pipelines would extend for a period of 12 months. It is foreseeable that pipeline construction would have a beneficial short-term impact on regional employment. This impact would be reflected in a slight percentage decrease in the unemployed civilian work force in the regional areas, particularly for construction workers. Secondary employment in commercial activities may increase to support construction related activities. However, this economic growth would be short-term and business activities would more than likely return to their preconstruction stage. The impact of the available project-related positions on a state and national level would be negligible.

It is expected that since most construction workers would be drawn from existing county labor pools, that the workers would probably commute daily to the construction site when it is relatively close to home. Transient accommodations would be sought as construction activities move beyond reasonable commuting distances. Relocation of families is not expected to be a widespread occurrence because of the mobility required of pipeline workers and the relatively short length of the pipeline routes. Permanent homes would most likely be maintained and temporary accommodations, in close proximity to the pipeline route, would be sought on a weekly or monthly basis. The migratory work force would place demands on local transient accommodations, however, no problems are foreseen in obtaining adequate, temporary rental units for individual workers. Many communities located in close proximity to the pipeline routes have many motels and hotels. In addition, mobile homes and camper parks are available and it is expected that some workers would rely on such transient housing. Overall, the construction phase for the two segments of pipeline should have no significant long-term impact on the existing housing characteristics of the communities situated in close proximity to the pipeline corridor.

The wages paid to the 700-man work force for the Point Conception to Arvin segment of pipeline is estimated at $26 million for a 12-month period and would primarily be distributed in Santa Barbara, San Luis Obispo, and Kern Counties. For the Arvin to Cajon segment of pipeline construction, the required 225-man work force would be paid $9.6 million in wages over a 12-month period. A substantial portion of these payrolls would be spent in communities along the pipeline route. The disposable income, calculated at 76 percent of the gross annual construction payroll, would be $19.8 million for the Point Conception to Arvin pipeline and the Arvin to Cajon pipeline payroll would yield approximately $7.29 million in disposable income. In addition to lodging, workers would purchase goods and services necessary for their daily needs and recreational desires. Economic benefits stemming from the purchase of goods and services would be limited by the short duration of construction in any one area, but the expenditures would stimulate the local economy and temporarily increase employment in service-oriented businesses.

Although the construction personnel would infuse new money into the local economies, it is unlikely that any businesses would suffer from overexpansion. Increased income, general sales, and excise taxes would provide a beneficial short-term impact in the state and communities throughout the project areas.

Building permit and plan check fees which would be paid to the traversed counties are based on the value of construction. These fees would represent an increased impact upon county revenues. Table 8.2.1-50 outlines the fees which would be generated in Santa Barbara, San Luis Obispo, and Kern Counties. No information is available for the Arvin to Cajon pipeline through Kern, Los Angeles, and San Bernardino Counties.

Operation of Pipelines--The operation of the proposed Point Conception to Arvin pipelines and the Arvin to Cajon pipeline would require a total of seven persons. A staff of this size would have an insignificant impact on

Table 8.2.1-50 Point Conception to Arvin pipeline permit and plan checking fees

	Counties			
	Santa Barbara	San Luis Obispo	Kern	Combined Impact
Permit value of construction within county (dollars in millions)	65.8	46.1	58.1	170.0
Project permit and plan checking fees	$269,000[1]	$77,000[2]	$104,000[3]	$450,000
Permit and plan checking fees as a percent of 1972-73 license and permit revenue	42%	35%	16%	30%
State of California surcharge[4]	--	--	--	$ 12,000
Total Fees (County and State)				$462,000

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[1] Santa Barbara County Department of Public Works, 1974.

[2] San Luis Obispo County, no date.

[3] Kern County, 1973.

[4] Surcharge imposed by California Division of Mines and Geology for seismic instrumentation. Reference: State of California Division of Mines and Geology, 1973.

Source: Federal Power Commission, 1975, Vol. III

the labor force and employment, population and housing, and urban services of the counties crossed by both routes. Employee payroll would have little effect on the counties' income profiles.

The completed gas transmission facilities from Point Conception to Arvin would have an estimated value of $217.7 million. Property taxes based on $209 million (excludes interest during construction) would add more than $5 million annually to the counties, agencies, and districts involved. The Arvin to Cajon pipeline would have an estimated value of $72.7 million. Property taxes based on $69.8 million (excludes interest during construction) would add more than $1.9 million annually within Kern, Los Angeles, and San Bernardino Counties.

Once in operation, agricultural activities could resume, creating little adverse economic effects upon existing crop planting or grazing activities. However, it is not known whether any orchards would be removed within the Arvin to Cajon right-of-way. If orchard removal is unavoidable, affected growers would suffer from a reduction in crop yield. This impact may be minimized if the applicant were to allow growers to replant certain varieties of fruit trees with shallow root systems. Even in this case, depending upon the age of the trees replanted, the fruit bearing stage may not be achieved for a significant time period. If orchard replanting is not feasible then the grower would suffer from potential economic loss for the duration of pipeline operation. Construction of permanent structures within the rights-of-way would be prohibited.

Land Use--

LNG Facility--

1. Onshore Construction. Construction of the proposed Point Conception LNG terminal would have immediate and long-term effects on present and future land use in Santa Barbara County. Cumulative effects would be substantial as the project would involve the installation of a major industrial facility in a primarily rural, agricultural area.

Presently, the proposed site and the local area are zoned 100-AL-O (Limited Agricultural) and the existing land uses are consistent with this zoning. The Limited Agricultural designation would allow oil-related development with county approval, a spot rezoning, and a conditional use permit. The construction of the LNG terminal would represent a major change in land use policy which presently recommends open space and/or grazing land uses for the site and other properties located along the coast from Point Conception to Gaviota. The proposed LNG terminal would represent a direct conflict with use of the land with respect to development of the Hollister Ranch parcels which would border the LNG site to the north and extend for many miles to the east. The proposed LNG facility would be visible from many areas of those parcels of land.

The adjoining property to the north and east of the property owned by SCE is held by the Hollister Ranch Corporation. As discussed in the Existing Land Use section, the Hollister Ranch has been divided into 135 parcels, each a minimum of 100 acres, which are being sold as exclusive home sites. This land is not considered a subdivision opportunity. The Hollister Ranch is one of the last of the large coastal ranches available for private ownership. Each parcel is purchased subject to a grazing lease as the ranch is operated as a working cattle ranch.

The construction of the LNG facility would introduce major industrial development into an area of agricultural preserve. The isolated impact at the construction site would be relatively low in juxtaposition to the impacts which would be incurred by the south coast region, as a whole, in relation to future industrial development.

As a result of the construction of the storage tanks and regasification facilities, grazing activities would be terminated on the project site and a total of 227 acres of open land would be converted to industrial use for the life of the project. The cryogenic LNG transfer line would be constructed between the offshore LNG berthing facilities and the regasification facilities. This transfer line would cross Southern Pacific Railroad's track atop a trestle. Rail service may experience minimal localized interference as a result of construction activity near the railroad right-of-way. In addition, temporary disturbance to rail traffic could occur from the construction of a railroad spur adjacent to the existing tracks. This spur would be utilized to offload construction materials. The large quantities of required equipment and materials would be stored near the immediate construction site.

The ingress and egress of vehicular traffic, generated by commuting workers and the movement of large trucks and construction equipment to the construction site would have a significant impact on the local traffic patterns for the duration of the construction period.

The principal access to the proposed LNG site is along a private road through the Hollister Ranch. This road extends west from U.S. Highway 101 at Gaviota Beach along the coastline and it is a winding, single-lane and partially developed road. An alternate site access route could be developed northwest of Point Conception. The Jalama Beach Road, a public road, intersects Highway 1 between Lompoc and U.S. 101. This road also follows a winding, narrow route through the foothills of the Santa Ynez Mountains to the Jalama Beach State Park. Due to the fact that this route is much steeper and more winding than the coastal access route, widening of this road would be more impractical.

If access is permitted along the private road from Gaviota Beach through the Hollister Ranch, all construction traffic would be funneled onto it. The road would require extensive preparation. Widening the road to provide two-lane access would involve the use of approximately 26 acres of land. Heavy traffic congestion and its localized impact would occur at the Gaviota Beach at-grade intersection with U.S. 101 during the morning and afternoon peak traffic periods. Current traffic counts are not available for this private road. However, based on the low population density of this area and the strict use restrictions which are applied, the average daily traffic count is estimated to be less than 100. Although the number of people using this road is small, the overall effect would be great, considering the conditions of the existing roadway.

Beyond the immediate site and access area, the construction phase of the project could induce some significant land use changes. The influx of construction workers to the region may require the development of transient housing facilities such as motels, trailer parks, and rental units. A small demand for residential housing may develop. The expansion of housing facilities would be accompanied with a demand for improved commercial and social services. This cumulative growth would significantly influence the urbanization rate of a primarily rural area.

2. Offshore Construction. Construction of the marine facilities would have a direct, conflicting impact on recreational and commercial use of the offshore areas. The construction activities associated with the installation of the docking facilities and trestle on approximately 31 acres

of leased state subtidal land, would impose temporary localized restrictions on any vessel using the area. Commercial fishing boats in the area would have to exercise caution to avoid interfering with construction activities and to avoid any possible collisions or damage to trawling equipment such as nets and otter boards. Recreational vessels would also run the risk of collision with barges and other construction vessels. Kelp harvesting would be excluded within the immediate vicinity of construction.

Within the inshore areas, where recreational use is more significant, several impacts would occur. Any swimming, scuba diving, surfing, and other beach-related activities would be eliminated.

3. Onshore Operation. Operation of the proposed project would have significant impacts on land use on a temporary and long-term basis. Approximately 101 acres of a total of 227 acres would be converted to an industrial use from an agricultural and open space use. Grazing activities would be excluded from the site area and the operation of the proposed LNG facility would have impacts on neighboring land uses, particularly in the Hollister Ranch area.

The purpose of the 100-acre minimum size of the parcels of land which are being sold for ranching and estate development is to help preserve the exclusive, rural nature of the area. The operation of the LNG facility would disrupt the seclusion that the homeowners desire, and would significantly change the low density character of the area. The coastal view would be marred, thereby affecting the esthetic nature of the area as well as adversely affecting property values at the Hollister Ranch. The visual quality of the existing environment is an important asset to the county.

The shoreline that extends from Jalama to Gaviota Beach is some of the most scenic in the county. The development of a designated scenic corridor would be dependent on the design and development of a shoreline drive. The proposed LNG terminal would degrade the quality and effect of such a plan along the coastal terrace. This impact would affect not only the present residents of the Hollister Ranch area but would affect the general public who would gain visual access all along the scenic corridor.

The trestle which would connect the offshore LNG berthing facility with the plant site would impact a small section of public beach where the trestle would cross the shoreline. This would be a minor impact as access to the beach in the site area is restricted. Access for those using the beach would be available to either side of the trestle, however, access to the trestle itself would be prohibited.

Vehicle traffic and circulation patterns would be affected as a result of the additional traffic generated by approximately 98 commuting workers and by the supply trucks which would service the vaporization site and ship stores. This impact would primarily affect ingress and egress traffic along the access road to the site, but would not be a significant impact on the volume of traffic on U.S. 101.

The most critical land use impacts that might result from this project are the cumulative effects and development implications which would concern future county and south coast land use. Land use development and related trends are controversial issues with the people of Santa Barbara County. Decisions relating to residential development and particularly petroleum production and processing have for some time agitated county concern. The 1968 sale of Outer Continental Shelf (OCS) leases increased petroleum exploration activity in the Santa Barbara Channel. In January 1969, a major blowout and oil spill along the public beaches was costly environmentally as well as in tangible economic losses to the community. Subsequently, a 5-year moratorium was imposed on all new drilling on existing state tideland leases. The moratorium was lifted in December 1973.

With renewed impetus, exploration and development of petroleum products has again proceeded. Exxon Pipeline Company of California proposed to construct and operate an offshore production platform and onshore treatment facilities in Las Flores Canyon. Public disfavor with the County Board of Supervisors 3-2 decision in favor of the project brought the controversial matter to a county referendum vote in May 1975. The final results of the referendum marginally favored the development of Exxon's facilities and emphasized the growing polarization on the subject between local citizens.

Residential developments have not progressed as rapidly as in other areas of southern California. In 1970, the proposed subdivision of El Capitan Ranch was defeated by a county referendum vote. Clearly, the formidable ramifications of industrial and residential development in Santa Barbara County are given much attention. The direction taken for county land use will depend greatly on an evaluation of state and county needs and their compatibility with the County General Plan.

4. Offshore Operation. Operation of the marine facilities could present a hazard to commercial and recreational boaters who venture too near the facilities. Commercial fishermen and kelp harvesters would have to avoid the immediate area. The presence of the marine facilities may affect recreational surfing. The local beach immediately adjoining the proposed LNG site, Cojo Reef, has been ranked by the Western Surfing Association (1974) as "Fair." Cojo Point, west of the site, is considered "Classic," Lefts and Rights, east of Barranca Honda and Gato, is rated "Good." Meanings of these terms follow:

> Classic--often an internationally known location that has been surfed for many years, receiving a great deal of publicity in both the general media and surf publications; and, as such, playing a key role in the heritage and history of the sport of surfing in California. In addition, a surf break with waves whose potential to size, quality and frequency in relation to other surf spots makes it a unique surfing resource.
>
> Good--Frequently provides waves of excellent size and quality.
>
> Fair--Provides waves of lesser frequency and quality.

There would be significant impact on traffic in the Santa Barbara Channel due to the large number of LNG ships traveling to the Point Conception site. The number of ship arrivals per year would depend on the capacity of the ships used. To meet the 2,806 million mmcfd rate, 300 ship arrivals per year using 165,000-cubic meter capacity ships would be required.

Pipeline Routes--

1. Pipeline Construction. Construction of the twin 42-inch pipelines from the Point Conception LNG facility to the proposed pressure regulating station at MP 133 would require a minimum 125-foot wide right-of-way. From MP 133, an additional 9.2 miles of 42-inch pipeline would be constructed which would extend north to the Arvin metering station. This 9.2 miles of

pipeline would require a 100-foot wide right-of-way during construction. These rights-of-way would extend for a total length of 142.3 miles and would traverse leased and purchased easements in Santa Barbara, San Luis Obispo, and Kern Counties.

During the construction phase a total of approximately 2,272 acres of land along the right-of-way would be cleared as work space for the pipeline construction. After installation of the pipeline a permanent 75-foot right-of-way or approximately 1,294 acres would be retained.

In Santa Barbara County approximately 55.5 miles (or 841 acres) would be disturbed during construction. Approximately 48.6 miles of the route would cross private land holdings and 6.9 miles would cross U.S. Forest Service lands (Los Padres National Forest). The entire route through this county is zoned with various designations for agricultural use. These categories include AL - Limited Agriculture, U - Unlimited Agriculture, and AG - General Agriculture. With the exception of the AL zoning, mineral production and processing is allowed in addition to agricultural use. In any area zoned AL or where the route would approach within 1,000 feet of such an area, a conditional use permit would be required.

In San Luis Obispo County, the pipeline route would disturb 27.8 miles of private lands or 421 acres, 6.5 miles of U.S. Forest Service lands or 99 acres, and 4.6 miles of Bureau of Land Management lands or 70 acres. The zoned areas through which the pipeline would cross permit a wide variety of land uses. Therefore, no zoning changes would be required. Currently, the land use allows the operation of public utility or public service buildings and structures for uses related to water, power, gas, and telephone transmission, storage, and generating facilities.

Approximately 47.9 miles of the pipeline route would be contained within the county limits of Kern County. Of this total, 36.1 miles of right-of-way land is privately owned and 2.6 miles is under the jurisdiction of the Bureau of Land Management. The land ownership of the remaining 9.2 miles of right-of-way has not yet been determined. The entire route in this county is zoned for exclusive agriculture which permits oil and gas production and pipeline construction.

The second segment of the proposed pipeline would extend for 108.9 miles from the Arvin metering station in Kern County, through Los Angeles County to the Cajon Station in San Bernardino County. This route would require a 100-foot wide cleared right-of-way. The pipeline construction would disturb a total of 1,330 acres, of which 10 acres would be occupied by temporary storage yards for pipe, construction materials, and equipment.

Unlike the first segment of the pipeline which crosses a significant amount of cultivated land, the Arvin to Cajon segment would encounter open space land use for approximately 95 percent of the proposed route. The open space uses include naturally-vegetated land, grazing land, and undeveloped subdivided land.

The 100-foot wide pipeline right-of-way would affect 60.9 miles of land or 738 acres in Kern County. A 5-acre parcel would be leveled for storage purposes and an additional 1.5 acres would be graded near Arvin for a metering station. Approximately 48.6 miles of the route would traverse privately owned land and the remaining 12.3 miles would cross federally owned land within Edwards Air Force Base.

Zoning along the Kern County portion of the route is the most diverse as compared to the rest of the route to Cajon. Areas zoned for agricultural, estate, suburban residential, and general manufacturing would be encountered. None of these zoning categories would preclude the installation and operation of public utility facilities including gas transmission pipelines. Approval for the 12.3 miles of pipeline right-of-way across Edwards AFB, must be obtained from the Base Commander and various federal agencies in Washington, D.C.

The proposed right-of-way in Los Angeles County would account for 14.2 miles (or 172 acres) of the pipeline route to Cajon. Private and Federal lands would each account for 7.1 miles of the route. No zoning changes would be required as the route passes through areas of open space and light agricultural activity. The 7.1 miles of right-of-way through Edwards AFB would require the same approvals as discussed in the previous paragraph.

From Los Angeles County, the pipeline route would cross into and terminate in San Bernardino County. The corridor would extend for 33.8 miles and would affect 410 acres. A 5-acre site would be selected and cleared for a storage yard and 1.5 acres would be utilized for a metering station at Adelanto. The first 31 miles would cross a combination of Bureau of Land Management and private lands. The final 2.8 miles are within the San Bernardino National Forest. The areas of contact are zoned for desert living, light agricultural, and rural residential and these areas do not preclude the construction of gas transmission pipelines.

Pipeline construction activities for the entire 251.2 miles of proposed pipeline construction would primarily occur in rural, unpopulated areas. Residential developments along the route are relatively scarce. Agricultural use of the land would incur significant impacts in the Point Conception to Arvin pipeline segment. Pipeline construction activities would result in the disruption of existing agricultural uses encountered along the entire length of the proposed pipeline. Farm equipment access across the right-of-way may also be hindered. Livestock grazing would be temporarily eliminated near the right-of-way areas and crop planting and harvesting schedules would be disrupted. Recultivation of these agricultural areas could not resume until after the termination of the construction phase. If orchard crossings are unavoidable, fruit trees occupying the right-of-way would be removed, thus reducing the fruit bearing potential of the land.

The residents of the Hollister Ranch, which adjoins the proposed LNG site, would be subjected to an increase in traffic along their private residential road. Pipeline construction would parallel the coastal bluffs and increased dust and noise levels would discourage recreational use along these bluffs. Cattle grazing would have to be temporarily terminated near construction activities.

In Santa Barbara and San Luis Obispo Counties, where the pipeline route would pass through Los Padres National Forest, recreational impacts may occur. Hiking, camping, horseback riding, fishing, swimming, and other recreational uses are common in the more rugged portions of the forest area. Construction noise and dust would temporarily discourage recreational use near pipeline construction activity.

Where the proposed route would cross thickly vegetated or tree covered slopes, a "tunnel effect" would be created. Potential beneficial use of these areas could be made as fire breaks, ecotones for fauna use in foraging, or recreational uses such as hiking and horseback riding.

Minimal impact to traffic on major thoroughfares and frequently used streets and roads would occur. All road and railroad crossings would be bored and cased to minimize disruption of traffic flow. Temporary delays could be experienced at these road or railroads due to the crossing of construction equipment.

In all areas along the pipeline routes from Point Conception to Arvin and from Arvin to Cajon where trails, and dirt or gravel roads are encountered, temporary detours and interruption of vehicle traffic would occur because these roads would be open-cut.

The California Aqueduct and the Los Angeles Aqueduct would each be crossed once by the pipeline easement. The pipeline would span the waterway above the main channels. Construction should not affect the flow of water at either site and no construction related impacts are expected.

2. Pipeline Operation. Once the pipeline has been installed, the right-of-way would be properly revegetated with native grass or cultivated crops. Restoration activity should allow the land to revert to its previous or other appropriate uses immediately following construction. A restriction on the construction of permanent structures would be imposed within the right-of-way. Land use would be restricted in areas where aboveground facilities would be situated. The visual impact of the right-of-way would be significant in the forested areas where trees would continually be cleared away for the life of the pipeline project.

Maintenance operations should have a minor impact on land use. Vehicle traffic associated with pipeline inspection should not have a significant impact on local traffic patterns. Access roads would be maintained in the mountainous regions near Tehachapi and Cajon. This may result in increased disturbance to wildlife.

Archeological and Historical Resources--An analysis of the impacts of construction on archeological resources is limited by several factors. First, the precise alignment of the pipeline has yet to be determined. Prior to construction a 2-mile wide corridor would be surveyed to provide the best alignment alternatives. Second, the existing data on known or potential archaeological resources are of variable quality with archaeological reports often differing in format, methodology, descriptive precision and in the qualification of the reporters themselves. Third and most important, no comprehensive field survey has been performed for the pipeline corridor, hence the actual numbers and locations of archaeological resources present cannot be known.

While it is impossible to define with any precision the impacts of pipeline construction on southern California archaeology, what can be discussed is the nature of the impacts that can be expected. The impacts associated with construction would be both direct and indirect. Direct impacts would arise from the actual construction of the pipeline and its associated facilities; the right-of-way, access roads, metering station, the LNG facilities and terminal, equipment yards and work areas. The proposed right-of-way would be 125 feet wide. The right-of-way and support facility sites would be cleared and graded. The pipeline trench would be 54 inches wide and from 60 to 80 inches deep. Machines would be used to dig the ditch except in rocky areas where blasting would take place. In such cases sites that would otherwise be outside the area of direct impact may be damaged.

Indirect impacts would arise from activities outside the actual construction of the pipeline. Foremost among these would be a greater incidence of souvenir collecting by construction workers at archaeological sites. Other indirect impacts could come about through soil erosion or chemical alterations in soils which would affect the integrity of archaeological sites.

Forty known sites have been located within the 2-mile wide pipeline corridor at the LNG plant site and offshore tanker facilities. The possibility exists that a large percentage of these, along with uncounted potential sites, would be disturbed by pipeline construction. Of principal concern is the location of the LNG facilities at Point Conception, which would impact large Chumash village sites. Also endangered by these facilities would be several underwater sites. Another area of concern is the Cajon terminus for the pipeline where 14 sites located in Crowder Canyon would be endangered by the construction activities at the proposed regulating and metering station.

A survey of the National Register of Historic Places indicates that no National Register properties would be affected by the proposed pipeline. The Los Alamos Ranch House near Los Alamos, California, would be about 1-1/2 miles west of the pipeline and no impacts are expected. In addition, it is not expected that any impacts would occur to the state landmarks which have been identified.

Air Quality--Gas fired peaking vaporizers and trim heaters would emit small amounts of nitrogen oxides, carbon dioxide and sulfur to the ambient air. The standby peaking vaporizers would use gas from the plant as fuel.

Emissions from the gas-fired vaporizers operating intermittently at maximum capacity should be approximately 0.06-0.12 lbs./MMBtu for NOx and 0.0007 lb./MMBtu for SOx. For trim heaters whose averaging firing rate is 200 MMBtu/hr, NOx emissions are approximately 0.13-0.18 lb./MMBtu and 0.0009 lb./MMBtu for SOx, therefore nitrogen oxides are of primary concern. Although these emissions would comply with appropriate emission regulations, the percentage increase above baseline ambient concentrations of pollutants in the Point Conception area appears to be large. These units, however would be designed to minimize the formation of nitrogen oxides during operation.

To estimate the maximum impact of the operation of the LNG facility on air quality both maximum emission rates and worst meteorological conditions were assumed. Emissions were assumed to emanate from an altitude equal to the stack height plus the plume rise (caused by plume buoyancy and momentum). At combustion temperatures, the formation of NO is thermodynamically favored over the formation of NO_2. Thus, in order to compute the annual average NO_2 contribution from the operations of the LNG facility, the effective NO_2 emission rate is equated to the total NO_x emission rate. The resulting annual average concentrations are less than 0.001 ppm, even with all sources operating full time. Thus, the annual average effect of nitrogen dioxide emission is less than 2 percent of the Federal standard (0.05 ppm).

Again using the Turner method (1969), for the combined sources, a conservative estimate for the worst 1-hour concentration is 0.06 ppm, occurring when all sources are operating and there is a strong sea breeze. With the more frequently occurring meteorological conditions (stability classes C and D), the worst 1 hour concentration is estimated at approximately 0.02 ppm. Therefore, the short term standard would not be exceeded unless the background concentration at Point Conception is greater than 0.23 ppm.

During the construction phase, there would be some additional vehicular emissions due to the influx of additional workers into the area but this increase should have an insignificant impact upon the ambient air quality of the region.

In addition, localized short term fugitive dust would occur as a result of construction activities and movements of equipment.

Noise--Noise sources at construction sites are very complex. Noise levels are a function of the numbers and types of equipment being used, operations being performed and size of the construction area.

All valves and metering devices will be buried, which will muffle noise levels normally associated with the operation of the proposed pipeline. Noise levels should attenuate to ambient levels within several hundred feet of these facilities, or within the confines of the right-of-way and the fence surrounding the metering station.

The proposed pipeline will not have compressor stations, which are the major noise source in any gas transmission system.

Impact on Local Utilities--It is estimated that the electrical power system required during the construction period would be required to supply an average electrical load of 5,000 kw. This system would probably operate on a 50 percent load factor during the 8-hour construction day, with about 600 kw/hr. needed for night lighting.

The electric power for construction would either be generated onsite with diesel generators or provided to the site through temporary connections from SCE's (kv) system in Gaviota. The jobsite is approximately 16 miles from Gaviota. If installed, the temporary connection would be removed after the facility has been completed and a higher capacity permanent electric transmission line from Goleta would take its place.

The electrical power requirements of the completed Point Conception LNG plant would necessitate some utility expansion at SCE's 220-66 kv Goleta substation. The permanent electric transmission line would have a 66 kv capacity and would be 35 miles long.

Preliminary planning by SCE indicates that no expansion of their generating capacity would be required to meet the power requirements. The cost of the substation expansion and transmission line from the substation to the plant site has been estimated to be between $3 million and $5 million. Rights-of-way for the 66-kv transmission line would have to be acquired. A typical right-of-way for the power line is 150 feet wide. An additional land area of up to one-half acre would be required for the expansion of the Goleta substation.

Comparing the estimated LNG plant load of 39,100 kw with the 1973 SCE Santa Barbara district average load of 96,150 kw indicates that the electrical requirements of the LNG plant would increase the SCE service district average load by slightly more than 40 percent. As stated previously the SCE generating plants in western Ventura County produce most of the power load in the Ventura-Santa Barbara region. The combined average power loads of the Santa Barbara district and the Ventura district totaled 291,940 kw in 1973. The Point Conception LNG plant load would increase this regional total by about 13.4 percent.

Estimated freshwater requirements for construction activities follow:

1. Sprinkling Water--for dust control and abatement: 30-50,000 gallons per day (gpd) for approximately 8 months per year.

2. Hydrostatic Test Water--for LNG storage tanks. Testing of the tanks would require approximately 11.5 million gallons if the same water can be reused for each tank. Water for the tests would be required at a rate of approximately 800,000 gpd.

3. Potable Water--for chemical flush toilets and field offices: approximately 10,000 gpd.

4. Concrete Mix Water--for structures and foundations: 2,500,000 gallons. Peak rate requirements would be approximately 100,000 gpd during the construction of the foundations for the LNG storage tanks. This operation would take place between the 5th and 20th month of construction.

Water for sanitary and domestic use at the completed facilities would be provided by the onsite seawater desalinization plant. The domestic sanitation system at the LNG facility would discharge an estimated 4,900 gpd of sewage into a sanitary sewage treatment system located on the plant site. No sewerage utilities would be affected by this project.

Water for fire protection would be provided by freshwater stored in an onsite 160,000-barrel storage tank, with a seawater backup. There would also be a seawater pump at the marine facilities.

Available freshwater sources to meet the water requirements for construction and for normal operations of the LNG terminal have not been identified. The construction of onsite water wells is one possibility. The alternative to onsite wells is to bring water to the site via pipeline. As noted in the section on existing utilities, a water moratorium presently is in effect in the project area. If local utilities import water from the State Water Project, then it is possible that the moratorium could be lifted and water made available to users, including Western LNG, who presently are not supplied by the existing water utilities.

There is insufficient groundwater hydrologic data available to determine whether enough freshwater is available at the site to meet the terminal's freshwater requirements.

The fuel gas required for operating the trim heaters, gas-fired vaporizers, and other equipment would be supplied from regasified LNG. Therefore, existing supplies of natural gas that have been committed to consumer markets would not be affected. Western LNG has estimated that the fuel gas requirements would be approximately 2,400 billion Btu's per year for plant operations. Assuming a thermal value of 1,160 Btu's per cubic foot of fuel gas, the use of gas-fired equipment as proposed would preempt the use by the general consumer of approximately 2,068 million Mcf of gas each year of terminal operations.

Analysis of Public Safety--

Introduction--The most significant hazard that could occur during the operation of the proposed LNG terminals would be the formation of a combustible vapor cloud and its subsequent dispersion and drift downwind into populated areas. The vapor cloud would be formed as the result of a spill of LNG. The larger the spill, the larger the vapor cloud and the further it could travel downwind over populated areas. A spill could occur over water from an LNG ship collision, or either over land or water from a rupture of an LNG storage tank.

Although there is little actual experience with the hazards to the public from LNG import terminals, there are data available from experiments involving small LNG spills, and analytical techniques for calculating vapor dispersion and drift. There is also available the accident experience involving the marine transportation and land based storage of other flammable liquids. This material has been used in the analysis given here. Some of the properties of liquid methane, which is the major component of LNG are tabulated below:

Selected Properties of Liquid Methane

Molecular wt. = 16. gm/mol
Density of gas @0°C = 0.717 gm/liter = 0.45 lb/ft^3
Density of gas @112°K = 1.75 gm/liter = 0.11 lb/ft^3
Density of liquid @109°K = 415 gm/liter = 25.9 lb/ft^3
Boiling point = 112°K = -161°C = -260°F
Heat of vaporization = 138 cal/gm = 248 Btu/lb

California Terminals--In terms of the risk from LNG compared to that from other involuntary risks normally encountered in daily life, LNG risks, to people onshore, from ship accidents are comparable in magnitude to those from fire, and electrocution. These appear to be acceptable risks for LNG importation by ship.

In order to study the effect of a massive LNG spill from storage tanks on shore a plume analysis was performed for the FPC by Meteorology Research, Inc. (MRI).

MRI assumed a 2,000,000-barrel spill from storage tanks at Point Conception, Oxnard, and Los Angeles Harbor, California. Computations were made on seasonal and annual bases of the Lower Flammable Limit (LFL) for each site using its climatology (winds, temperature, stability). One analysis considered the LNG-water interactions using a Gaussian diffusion model under the neutral stability conditions. Another LFL analysis was made considering both land and water interactions with LNG and using the MRI three-dimensional diffusion model which includes terrain and soil characteristics. The MRI landwater model provides the most accurate results and the most significant indication of differences between sites.

Table 8.2.1-51 shows the downwind distances to reach one LFL derived from these models. Table 8.2.1-52 shows the standard deviations associated with these values of LFL for the Gaussian model. The MRI model results in longer distances to reach the LFL. The reasons are: (1) the virtual-point concept is based on data from a relatively warmer cloud than the LNG, the latter being very cold compared to the ambient atmosphere; (2) the z for LNG dispersion should be smaller than those based on data from clouds from hot stacks; (3) the Gaussian model does not take into account terrain features or variations of meteorological parameters such as the wind.

For Point Conception, the effect on the wind field distributions of the 12.2 m (40 ft) drop from the proposed site to the beach below was considered in the MRI model. The resulting LFL distance was 12.0 km (7 miles) as compared to 12.5 km when flat terrain is assumed. The lower LFL is due to the higher average wind speeds at the higher (40 ft) level which causes the plume to make contact with the ground sooner and at a shorter distance from the spill. For the other two proposed sites at Oxnard and Los Angeles

Table 8.2.1-51 Downwind distance to reach one LFL for Gaussian and MRI diffusion models (km)

Continuous Release	Wind speed (m/s)	Point Conception			Oxnard			Los Angeles Harbor		
		Gaussian	MRI		Gaussian	MRI		Gaussian	MRI	
			Water	Land-Water		Water	Land-Water		Water	Land-Water
	2.24	9.13	9.65	12.0	9.13	9.65	12.73	9.13	9.65	12.5
Summer	3.91	4.65	6.50	11.5						
	3.86				4.71	6.25	11.8			
	3.66							5.04	7.20	11.5
Winter	3.09	6.22	7.60	11.0						
	4.74				3.65	3.90	7.75			
	2.78							7.06	8.0	10.5
Annual	4.90	3.47								
	4.20				4.22					
	3.90							4.68		

Source: Federal Power Commission, 1975, Vol. III

Table 8.2.1-52 Values of σ_y and σ_z (m) for Gaussian diffusion model for "D" stability

		Point Conception		Oxnard		Los Angeles Harbor	
		σ_y	σ_z	σ_y	σ_z	σ_y	σ_z
Continuous Release	5 mph (2.24 m/s)	1360	128	1360	128	1360	128
Summer (m/sec)	3.91	1160	84.9				
	3.86			1170	85.5		
	3.66					1180	89.1
Winter (m/sec)	3.09	1230	101				
	4.74			1120	72.7		
	2.78					1270	109
Annual (m/sec)	4.90	1110	71.1				
	4.20			1150	80.0		
	3.90					1170	85.0

Source: Federal Power Commission, 1975, Vol. III

Harbor, such terrain effects are found to be negligible resulting in distances to one IFL equal to those given in Table 8.2.1-51.

Arvin, California to Eastern United States

Climate--Construction of proposed pipeline should have an insignificant impact upon the climate.

Topography--Temporary access roads would be constructed for trucks, construction equipment, and personnel-carrying vehicles where local roads are not available. Vegetation would be cleared, the surface soil would be disturbed and, depending on the terrain, there would be minor topographic changes due to grading of the roads.

There would be minor changes of land features in rocky areas where the use of explosives would be required to excavate the right-of-way. The size and spacing of explosive charges would be set to minimize and retain spoil within the right-of-way. Spoil, resulting from blasting, would be utilized as backfill wherever needed and any excess would be graded into the right-of-way.

Borrow pits could either be filled in or left open to be used as stock watering ponds, depending on landowner desires. Those to be filled in would be backfilled using the spoils from pipeline trenching and, if required, would be graded and reseeded.

Each compressor station site would be cleared, graded, and surfaced with 6 to 10 inches of free-draining compacted material.

Geology--No significant impacts are anticipated related to geologic resources.

Soils--Construction of the proposed project would require the clearing of about 4,000 acres of land for the pipeline right-of-way, and less than 600 acres for the compressor stations, access roads, borrow pits, holding ponds, and storage areas. The clearing operations would temporarily expose the surface soils. Some wind and water erosion would occur in the cleared areas until revegetation of the ground cover occurs. Soil would be lost on cleared, steep slopes in the Edwards Plateau due to water runoff, with resulting delay in the reestablishment of vegetation. A period of little or no rainfall would also hinder revegetation and allow the wind erosion of soil in the cleared regions.

The construction of the proposed pipeline would require the use of ditching machines to cut a trench deep enough and wide enough to accommodate the pipe and to provide adequate soil cover when the pipeline is positioned in the trench. The machine would place the surface and subsurface soils together along one side of the trench. After the pipeline is emplaced, the trench would be backfilled with the topsoil mixed in with the less fertile lower layers, causing the trenched areas to be less fertile and therefore less productive. Paved roads and railroads would be crossed using the bore and casement method to prevent disruption of vehicular and train traffic. Existing pipelines to be crossed would be exposed by hand and machine trenching, and would receive proper structural support. Farm land would be trenched using the double-ditching method.

Water Resources--The effects of construction on water quality would be primarily temporary in nature. Stream crossing operations and runoff from adjacent denuded areas could create increase suspended sediments. Increased turbidity would cause a reduction in photosynthesis resulting in a reduction of oxygen concentration. This could create a deficiency for both aquatic plants and animals. This state of lowered productivity would be restricted to the areas of high turbidity and would last until the suspended sediments settle or are dispersed by streamflow.

Alteration of water quality could occur from disturbing the stream bottoms. The effects of these changes would vary according to the types of chemicals released. Toxins or chemicals that would cause large shifts in pH could seriously lower the productivity of the affected area. Release of extra nutrients could be beneficial as food for stream organisms. However, in instances where added nutrients create excessive algal blooms, the results could be detrimental because of the oxygen deficit created by increased decomposition and respiration. All such changes would be temporary and conditions would tend to return to normal shortly after construction is completed.

The major effects of hydrostatic testing would arise from removal of water from local sources, excavation of holding ponds, discharge of test water, and disposition of holding ponds after construction.

Around 670,000 gallons of water would be required for each 5-mile section of pipeline. This water would be withdrawn from local sources (rivers, wells, lakes) in quantities that would not adversely affect the supply source and therefore should not create any long-term effects on water quantity or quality.

The excavation of holding ponds adjacent to the pipeline right-of-way would have impact similar to that of borrow pit excavation and therefore should not create any long-range adverse effects. In fact, the ponds could be utilized as stock watering tanks and also as fish and waterfowl habitat.

Water would be returned to its source by fan sprays or other such methods to minimize the possibility of erosion or siltation.

Vegetation--Vegetation within the proposed 60-foot right-of-way and within the areas of aboveground facilities would be destroyed during construction. Cut trees and other vegetation would be cut and stacked along the proposed right-of-way, and debris would be burned or transported to offsite disposal areas. At all construction sites, the disturbed land would be either seeded with grass indigenous to the area or allowed to naturally revegetate, depending on the landowner's prerogative. All farmers would be reimbursed for any crop losses. However, for maintenance purposes, no trees or shrub growth would be allowed in the proposed right-of-way. The removal of vegetation would destroy the present developmental stage of the plant community. Any cleared areas would be susceptible to increased erosion, which would decrease the productivity of the soil in addition to the decrease caused by mixing the soil layers during trenching. Areas not seeded would undergo secondary ecological succession, with the establishment of pioneer vegetation within several growing seasons and development of the final climax community in 20 to 40 years.

Wildlife--The temporary effects of the proposed construction on wildlife would result from disruption of soil, loss of vegetation and wildlife habitat, increased dust, noise, vehicular traffic and human presence.

The most affected group would be the invertebrate fauna. The lack of swift movement of most invertebrates and their basically fossorial habitat renders them helpless to escape the disruption of their substratum as a direct result of being unearthed by the excavation process. However, since the area of land involved is relatively small in comparison to the total land area surrounding the route and as the number of invertebrates is generally high, the actual long-term effects should be minimal.

The next most affected faunal groups would be the burrowing and ground nesting species of vertebrates. Included among these would be small rodents, lizards, tortoises, armadillos, prairie dogs, foxes, badgers and other fossorial animals. The construction work would temporarily destroy the habitat of these species forcing them to seek out suitable habitat in areas adjacent to the construction zone. The success of these relocations would depend on the availability of suitable habitat and the carrying capacity of the area.

The majority of these species are non-game animals. Information concerning population densities and carrying capacity of such animals is inadequate for quantifying the impact of the project upon them. Such studies are presently underway by the Texas Parks and Wildlife Department and should be available in the near future. This displacement could cause the more territorial species some problems in obtaining food and shelter. The cleared right-of-way and access roads could interfere with the daily movement of some species but should act as only temporary barriers. The loss of ground vegetation, while consisting of only 0.022 percent of the total acreage crossed, would result in loss of cover and food for mice and other ground dwellers. Ground nesting species such as quail, pheasant, dove, and other upland game birds would also lose cover, food sources, and nesting sites as a result of vegetation removal. The clearing of trees and shrubs would result in loss of this vegetation type during the life of the project, since maintenance procedures call for their periodic cutback to keep the right-of-way passable. This would result in loss of nesting sites for various song birds and other arboreal species as well as roosts for dove and wild turkeys. Browse for deer, especially oaks, would also be lost.

The increased dust, noise and traffic along the construction route would probably cause temporary behavioral changes among some species resulting in decreased nesting sites and permanent relocation away from human activity. Increased vehicular traffic could result in increased loss of wildlife from road kills, especially among jackrabbits, deer, skunks, snakes and small rodents whose territories would be transected by the right-of-way and access roads.

Blasting along the right-of-way would frighten wildlife and possibly result in the loss of some ground dwelling species. The borrow pits created by construction could result in loss of habitat for burrowing forms, but could also create habitat for certain other species such as frogs, salamanders, fish and waterfowl. Blasting could also cause decreased nesting success and/or result in relocation of nesting sites.

The effects of construction on the aquatic habitat would arise primarily from stream and river crossing and surface runoff from cleared areas. These effects would be only temporary, and would be restricted to relatively small, downstream portions of the waterways so that overall these areas should not be greatly affected.

Two major results of construction activity would consist of siltation and the release of chemicals previously bound in the soil. The general effect of siltation on the aquatic environment is to severely reduce both the kinds of organisms present and their population numbers.

As particulate matter settles to the stream bottom it creates undesirable physical environments for the organisms normally present. These undesirable areas are created by the screening out of sunlight, changing of heat radiation, formation of a silt layer on the stream bottom, and release or introduction of organic materials or other substances, such as heavy metals, that may create toxic conditions. Eggs and larval stages of various organisms could be smothered; fish feeding would be hampered and spawning areas could be lost. Accumulation of sediment would cut off oxygen and food supplies to benthic organisms, and small pools used for breeding by certain aquatic organisms would be filled in and lost.

The effects of construction on rare or endangered species would vary depending on each particular species encountered and the steps taken to avoid adverse effects on each. However, since the area to be disturbed is so small in comparison to suitable surrounding habitat, there should be no long range threat to any of the less range-restricted species.

The black-tailed prairie dog and black-footed ferret are so closely associated as prey and predator, respectively, that the effects on the prairie dog would directly affect the ferret. Construction practices could result in a small loss of habitat for the prairie dog. Since the prairie dog feeds on many types of green vegetation, the loss of vegetation would only temporarily alter the foraging routine of any prairie dogs located near the denuded areas. There has been a recent population explosion of the prairie dogs to the point of their becoming a problem in certain areas. There have been no sightings of ferrets in Texas and it is believed that they may now be extinct there.

The possible range of the red wolf reaches into both the Gulf Prairie and South Texas Plains regions. Current reports indicate its range is primarily limited to four southeastern Gulf Coast counties of Texas and adjacent Louisiana. However, there have been reported sightings in Refugio County, during the 1960's, so the possibility of encountering this species does exist. Since these animals are very mobile there should be no direct threat to them from the temporary disruption of the narrow right-of-way.

The extremely rare occurrence of the Mexican wolf in the area of proposed construction would tend to suggest that the area is only used as a hunting ground and not for breeding purposes. Therefore, the proposed construction would have little, if any, impact on these animals. However, if the area does become part of the breeding ground, then destruction of usable burrows during the reproduction season (March-June) could have a detrimental effect and should be avoided.

The desert fox, which occurs in the desert lands of the Trans-Pecos region, could be encountered during construction. Since they are den-dwelling animals, construction activities would destroy dens which might be along the pipeline right-of-way. However, since these are wary animals it is unlikely that they would be encountered.

The ocelot, which may be found along the Gulf Coast and in southern Texas, is not likely to be encountered in the construction area because of its secretive behavior and avoidance of man.

The cougar is a secretive cat which could possibly be encountered in the more mountainous or canyon-type localities. Because of its mobility there should be little or no adverse effects on this large carnivore.

The southern bald eagle, which is primarily found in estuarian areas of the Gulf Coast, could be occasionally encountered along the route during some of its migratory visits inland. Cutting of trees, especially along streams, could be detrimental because of the loss of possible nesting sites. The Texas Parks and Wildlife Department has indicated the presence of an existing nesting site in Refugio County, so that precautions should be taken to avoid destruction of possible nesting trees.

The Arctic peregrine falcon is a winter visitor found primarily around the coast and in open country inland. The American peregrine falcon is believed to nest in the mountains in west Texas but specific aerie locations are not known. Special care will need to be exercised if they are found in the vicinity of the corridor.

Attwater's greater prairie chicken, which resides in small separated populations in the tall-grass prairies, could be adversely affected if these tall-grass habitats are destroyed. Any further reduction of prairie can be expected to further stress this species. Especially important will be the terminal 20 miles of the Waha-Refugio corridor as this traverses one of the two counties regarded as the principal range remaining for the Attwater's prairie chicken. Placement of the line so as to avoid such areas would reduce this impact.

The burrowing owl, which occurs all along the proposed route, would be adversely affected by loss of burrow shelters, but could also benefit from increased exposure of small rodents because of temporary loss of habitat from construction activity.

The black-capped vireo is a resident of scrub-oak and brushy hillsides and could be adversely affected by loss of such habitat during construction.

The golden-cheeked warbler, which breeds only in Texas, nests in juniper-oak canyons. It would be adversely affected by loss of its habitat because of increased exposure to predators and loss of breeding sites. These oak-juniper areas should be avoided in order to save this rapidly vanishing habitat type.

The whooping crane is primarily confined to the Aransas National Wildlife Refuge during the wintering season. During fall and spring migrations the whoopers generally utilize other lands along their Canada-Texas migration route, therefore there is some chance they may be encountered along the proposed pipeline route. However, the chance of this occurrence is remote. Since there are no established feeding or resting sites along the route the proposed project should have little if any impact on this species.

Due to the distant location of their restricted underground water habitat, the Valdina Farms salamander and Texas blind salamander are not likely to be encountered by project associated construction activities. However, if those waters in which they live were drained for use as test water there would be an adverse impact.

The American alligator is a coastal form not likely to be disturbed since the proposed route does not cross or pass near any marsh areas. However, drainage of area marshes or waterways for construction would result in loss of habitat for this endangered species.

The toothless blindcat is a rare cave-dwelling fish that is found in artesian wells near the San Antonio area. Withdrawal of large amounts of artesian water, and/or dumping of contaminated water into such wells should be avoided as it could cause further dieoff of this species.

The widemouth blindcat is found in artesian wells of the Edwards limestone area. Again, withdrawal of large amounts of such water, or dumping of contaminated water into wells could cause adverse effects.

The Comanche Springs pupfish, which is restricted to the outflow of Phantom Lake Springs near Toyahvale; the Clear Creek gambusia, found in the headwaters of Clear Creek; the Pecos gambusia, restricted to spring fed ditches around Toyahvale; and the fountain darter, confined to springs in Hays and Comal Counties, are all endangered fish species that should not be affected because of the unlikely use of water from the distant sources they occupy.

Ecological Considerations--With few exceptions, the proposed corridors will traverse land which is not highly vulnerable to the types of changes which accompany pipeline construction and operation. In contrast to the Alaska segment, topography, soils and climate do not create technically and ecologically difficult problems in excavation. Most plant communities have undergone earlier disruptions and therefore exist in a state of disclimax. In general, the wildlife which exists typifies this type of life system or is adapted to it. Such ecosystems exist by virtue of the resilience of the members to accept temporary disruptions of the land and vegetation.

Sociologic and Economic Factors--The socio-economic effects of the proposed pipeline would be temporary because the transient nature of the work crews would not require or permit the establishment of construction communities.

It is anticipated that the proposed project would require less than a year to complete. Work crews would cover about 15 miles of pipeline every 10 days or so.

The proposed pipeline construction would involve up to 1,500 workers, divided into spreads of 150 to 300 men each. Sanitary wastes would be buried or transported to appropriate disposal sites.

The major economic results of this construction would include increased revenue for the surrounding communities through increased sales of food, clothing and other essentials. There would be temporary increases in vehicular traffic; use of housing in some nearby communities, increased demands on public services and possibly construction associated employment for local workers.

With regard to population growth trends, it is unlikely that pipeline construction would greatly affect the net population at either the regional or local level.

The construction of the compressor stations would tend to create more lasting effects. Each compressor site would require a crew of up to 100 workers for a 4 to 5-month period. The same economic results occurring from pipeline construction would also result from compressor station construction, but would last longer at specific locations. In addition to increased revenue, the presence of up to 100 workers, plus some families would cause significant population increases to the sparsely populated towns near the construction sites. Some additional housing in the form of house trailers would be required if adequate numbers of boarding rooms and motels are not available. Depending on how many families of workers accompany them to these towns there could also be temporary overcrowding of local schools.

streams, could be detrimental because of the loss of possible nesting sites. The Texas Parks and Wildlife Department has indicated the presence of an existing nesting site in Refugio County, so that precautions should be taken to avoid destruction of possible nesting trees.

The Arctic peregrine falcon is a winter visitor found primarily around the coast and in open country inland. The American peregrine falcon is believed to nest in the mountains in west Texas but specific aerie locations are not known. Special care will need to be exercised if they are found in the vicinity of the corridor.

Attwater's greater prairie chicken, which resides in small separated populations in the tall-grass prairies, could be adversely affected if these tall-grass habitats are destroyed. Any further reduction of prairie can be expected to further stress this species. Especially important will be the terminal 20 miles of the Waha-Refugio corridor as this traverses one of the two counties regarded as the principal range remaining for the Attwater's prairie chicken. Placement of the line so as to avoid such areas would reduce this impact.

The burrowing owl, which occurs all along the proposed route, would be adversely affected by loss of burrow shelters, but could also benefit from increased exposure of small rodents because of temporary loss of habitat from construction activity.

The black-capped vireo is a resident of scrub-oak and brushy hillsides and could be adversely affected by loss of such habitat during construction.

The golden-cheeked warbler, which breeds only in Texas, nests in juniper-oak canyons. It would be adversely affected by loss of its habitat because of increased exposure to predators and loss of breeding sites. These oak-juniper areas should be avoided in order to save this rapidly vanishing habitat type.

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The major aesthetic effects of pipeline construction would largely depend upon the success of revegetation along the right-of-way and the return of borrow pit and holding pond areas to their preconstruction state. The most noticeable effects would occur primarily in the Edwards Plateau where trees removed from the right-of-way would produce evident open strips in the natural landscape. The majority of non-woody vegetation would be replaced through reseeding and natural regenerative processes.

The aesthetic effects of aboveground installations would be limited by the small areas involved and their remote locations.

Land Use--Construction of the pipeline, compressor stations and related facilities would necessitate some restrictions on land use in the immediate area. Cultivated land located within the right-of-way would be available for farming immediately after completion of construction, but grazing would be interrupted for several seasons until the restoration of vegetation on right-of-way land is completed. Areas of scenic or recreational use would not be affected. Compaction of soil by heavy equipment would be detrimental to seeding and germination and would reduce groundwater percolation unless the soil was plowed up and disced following completion of construction. Land where the proposed compressor stations and other permanent aboveground facilities would be located would be unavailable for any other uses for the life of the project. In addition, the fertility of this soil would be reduced for the duration of the project, because without vegetative cover, the content of organic matter in the soil would decrease and soil nutrients would be leached out.

Upon termination of the useful life of the project, removal of all aboveground facilities would allow the areas occupied by those facilities to revert back to their natural state or else be revegetated according to landowner wishes. Obvious differences in the land surface and vegetation would exist for a period of time; however, the use of the land would return to its preconstruction state.

In the event the pipeline is abandoned in place, several long-term effects could result, especially in irrigated areas. The use of modern-day epoxy coatings, thorough wrapping techniques, and cathodic protection greatly reduce the occurrence of pipeline deterioration during operation. However, after termination of operation, the factors of rust and corrosion would increase, possibly resulting in eventual weak spots and cave-ins of the pipeline. These cave-ins would cause subsidence of the land directly above the pipeline requiring the use of land fill. If long sections of pipeline were to cave-in, it would create a small gully which would increase drainage and erosion of the immediately surrounding area. This could result in the pipeline becoming filled with water and/or mud in areas of high moisture content such as irrigated farmland. This would create boggy areas which would be useless for farming and hazardous to livestock.

Presence of the buried pipeline could create problems with excavation projects, requiring extra time and expense for removal of the pipe. Also, construction of highways, railways, buildings or any other structures of great weight would require removal of the pipe to avoid possible cave-ins. These impacts could be eliminated by removal of the pipeline upon termination of the project, or by filling the abandoned pipeline with a suitable compactable material which would prevent the possibility of any cave-ins.

Paleontological, Archaeological and Historical Resources--Numerous sites of archaeological and historical significance are present in the corridor which spans 50 miles either side of the proposed pipelines. However, the number that lie within the zone of direct effect is small. It is important that a survey be conducted in order that construction can be planned so that no significant damage is done. If proper precautions are not used during the construction period, trenching and other excavation activities could result in the irreversible commitment of archaeological resources.

Recreation and Aesthetic Resources--No major recreation facilities or aesthetic resources other than Buffalo Lake National Wildlife Refuge are located within the zone of immediate influences from the pipeline. With the exercise of reasonable care in planning, constructing and operating the pipeline, no significant impacts are expected.

Air Quality and Noise--During the period of construction, vehicles and other machinery will produce increases in emissions and noise. However, these effects will be temporary. During operations, noise will be produced by the compressor stations. Noise emanating from the compressor units and associated power sources will be continuous but of low intensity. That produced by periodic blow-downs will be of high intensity but very infrequent (approximately twice each year). The impacts produced will depend principally upon the placement of these stations relative to population centers.

Operation and Maintenance--

Climate--The operation and maintenance of the proposed pipeline system should not have a significant impact upon the environment.

Land Features, Use and Vegetation--The effects of operation and maintenance on land use would be minimal. Less than 100 right-of-way acres would be devoted to aboveground facilities.

There would be a loss of small areas of woody plants and some larger areas of herbaceous growth, resulting in slight alteration of existing habitats. Reseeding and establishment of grasses and forbs should occur after several growing seasons resulting in revegetation of the area.

Areas that were used for crop and pasture land prior to construction would be reestablished following completion of pipeline construction, therefore, operation and maintenance would have little, if any, long-term effects on land use in these areas.

Noise--The effects of the proposed compressor stations on noise levels can only be estimated since the final noise control design, plant layout and equipment selections have not been made. Therefore, noise levels anticipated at the various stations and station boundaries were tabulated using measurements of similar existing installations and should be representative of the projected noise levels. The expected mean noise level at each of the compressor stations would range between 83 and 85 decibels.

Wildlife--The impact of operation and maintenance on local wildlife would also be minimal. It would consist primarily of periodic interruptions in the normal daily routine of resident species by occasional pipeline patrols, and altered behavior patterns of species occupying habitats immediately adjacent to the compressor stations due to human presence and activity. The increased noise levels resulting from compressor operation could cause relocation of certain species such as wild turkeys, which prefer relatively quiet and secluded areas for roosting and nesting.

Air and Water Quality--The NO_2 emission rates of the proposed compressor stations would range up to 42.9 lbs/hr. The results of diffusion calculations, which take into account emission rate, air stability, frequency of wind direction and average wind speed, give the average annual ground level concentrations for NO_2. The highest concentrations were calculated to occur generally in a northwesterly-to-northerly direction at distances between 200 and 500 meters downwind. These calculations predict additional average annual ground-level concentrations of less than 5 $\mu g/m^3$ for the Refugio station and less than 6 $\mu g/m^3$ for other stations. When these additional quantities are added to the existing quantities of NO_2 the resulting levels of NO_2 (maximum 27 $\mu g/m^3$) would be well below the state and Federal limits of 100 $\mu g/m^3$.

Sanitary waste treatment would involve either attachment to local municipal waste treatment facilities if accessible or use of approved septic tanks, and should not adversely affect the local water quality.

Water supplies would either come from municipal water sources or wells which would be drilled to provide water for the resident operational crews.

Socio-Economic--Operational crews would consist of one or two employees and their families living at each station camp. Their daily needs would cause a very slight increase in total spending in the local area and require use of nearby public services, schools, and hospitals.

The possible use of local residents for operating crews would create an insignificant rise in employment which would have only minor socio-economic effects.

The major economic benefits that would arise from construction and operation of the proposed project would consist of taxes and associated revenues.

8.2.2 Variation: Prudhoe Bay To Cook Inlet - Alaska

The subject corridor to Cook Inlet is a variation routing to serve the purpose of transportation of Arctic Slope gas by means of a large-diameter pipeline to the southern coast of Alaska, where it could be liquefied and shipped by cryogenic tankers to the west coast of the United States.

Description of the Project

Reference is made to Figure 8.2.1-2. Location of a proposed LNG plant and marine terminal on Cook Inlet would require a gas pipeline route generally paralleling the Alyeska oil pipeline and highway route south from Prudhoe Bay, across the Brooks Range and south to the vicinity of Fairbanks. It would then continue south along the corridor utilized by the Alaska Railroad and Fairbanks to Anchorage State Highway. Passing on the east side of Anchorage, the routing would continue south, crossing underneath the waters of Turnagain Arm to the Kenai Peninsula where it would travel overland to Nikiski (Nikishka), a locality on the east bank of Upper Cook Inlet. The distance from the diversion point at Fairbanks to Nikiski would be approximately 425 miles. This portion of the route would cross 150 small creeks, three major rivers - the Tanana River (1,320-foot crossing), Healy Creek (990 ft. crossing) and Susitna River (660 ft. crossing), Cook Inlet (Approx. 16 miles) and would require a 660-foot aerial crossing at Hurricane Gulch. Total length of the route, from Prudhoe Bay to Nikiski, would be approximately 850 miles.

Compressor stations would be spaced approximately 60 miles apart. Where convenient, and when road access is good, maintenance and construction camps would be sited with compressor stations.

This variation would lengthen the tanker shipping route to Southern California by approximately 150 nautical miles. Thirteen tankers would be needed for the LNG fleet.

The LNG plant and marine loading site for this alternative was chosen at Nikiski which is approximately 9 miles north of the City of Kenai and 65 miles to the southwest of Anchorage. The site is bounded by Cook Inlet on the west and by an existing petrochemical industrial complex on the north and south. Another site, located at Cape Starichkof was considered, but was rejected.

As the result of an extensive overall evaluation of the physical, biological, and socioeconomic characteristics of the Nikiski and Cape Starichkof LNG Terminal sites, the former location was found superior. Both sites are similar in seismic and geologic features but differ markedly when marine-related criteria are considered. Currents are stronger at Nikiski than off Cape Starichkof, and sea ice is never as prevalent at Cape Starichkof as it is near Nikiski. Neither ice nor currents pose a serious problem below the Forelands on the east side of Cook Inlet, however. The greatest difficulty at Nikiski would be possible conflicts with nearby shipping and docking operations, a problem not faced at Cape Starichkof. On the other hand, shoal areas near Cape Starichkof would probably require more extensive dredging than such areas near Nikiski, and the pier required for a marine terminal at Cape Starichkof would be 1,000 feet longer than one at Nikiski. The supply pipeline route to Starichkof would also be 50 miles longer and require four more major river crossings than the route to Nikiski.

Less biological impact would be expected at Nikiski than at Cape Starichkof because of the industrial surroundings, the lack of nearby anadromous fish streams or clam beds, and the highly turbid estuarine waters at Nikiski. The Cape Starichkof site, on the other hand, is in a relatively undisturbed area, is adjacent to a major anadromous fish stream and well-known clam beds, and usually lies within a region of relative water clarity. In general, the Cape Starichkof area is more sensitive biologically than the area around Nikiski.

Some of the biological characteristics of the Cape Starichkof area make it less acceptable from a socioeconomic standpoint. Cape Starichkof is valued primarily for its hunting, fishing, and clam digging. The only use made of recreational resources in the Nikiski area takes place at a public campground.

Locating an LNG plant at Cape Starichkof would conflict with existing land use, which would not be the case at Nikiski. Finally, the large population base and resource of public services in the Nikiski-Kenai-Soldotna area would be better able to absorb the population increase associated with an LNG project than would the smaller towns of Happy Valley and Anchor Point near Cape Starichkof.

The basic design, description and number of facilities, construction scheduling and procedures, presented in Section 8.2.1, Description of the Project, is applicable to this alternative project proposal.

The Cook Inlet route skirts the western extremity of the Kandik Petroleum Basin, passes through the Middle Tanana Basin and the Upper Cook Inlet Basin. The Kandik and Middle Tanana Basins are potentially petroliferous but the gas potential is considered minor in comparison to the Arctic Slope where the corridor originates. The Upper Cook Inlet Basin, the terminus of the corridor, is an active petroleum exploration and producing province.

Refer to the discussion in 8.2.1 for consideration of the marine route.

Description of the Existing Environment

Refer to Section 8.2.1, Description of the Environment, for a description of the environment along the route between Prudhoe Bay and Fairbanks.

Climate

The route is primarily within the continental climatic zone of Alaska previously described in Section 8.2.1, Description of the Environment. Somewhere in the Susitna River basin the route enters the transition climatic zone also described in 8.2.1. Refer to Figure 8.2.2-1 showing climatic zones and the route.

Temperature

The mean annual temperature in the area north of the Alaska Range from about 24°F to 29°F, south of the Alaska Range the mean annual temperature is about 29°F in the more northerly part and 38°F in the Cook Inlet area.

Extremes range from -60° to nearly 100°F north of the Alaska Range, South of the range extremes range from about -40° to 85°F. Refer to Figure 8.2.2-2 and 3 respectively for mean January minimum and mean July maximum temperatures along the route.

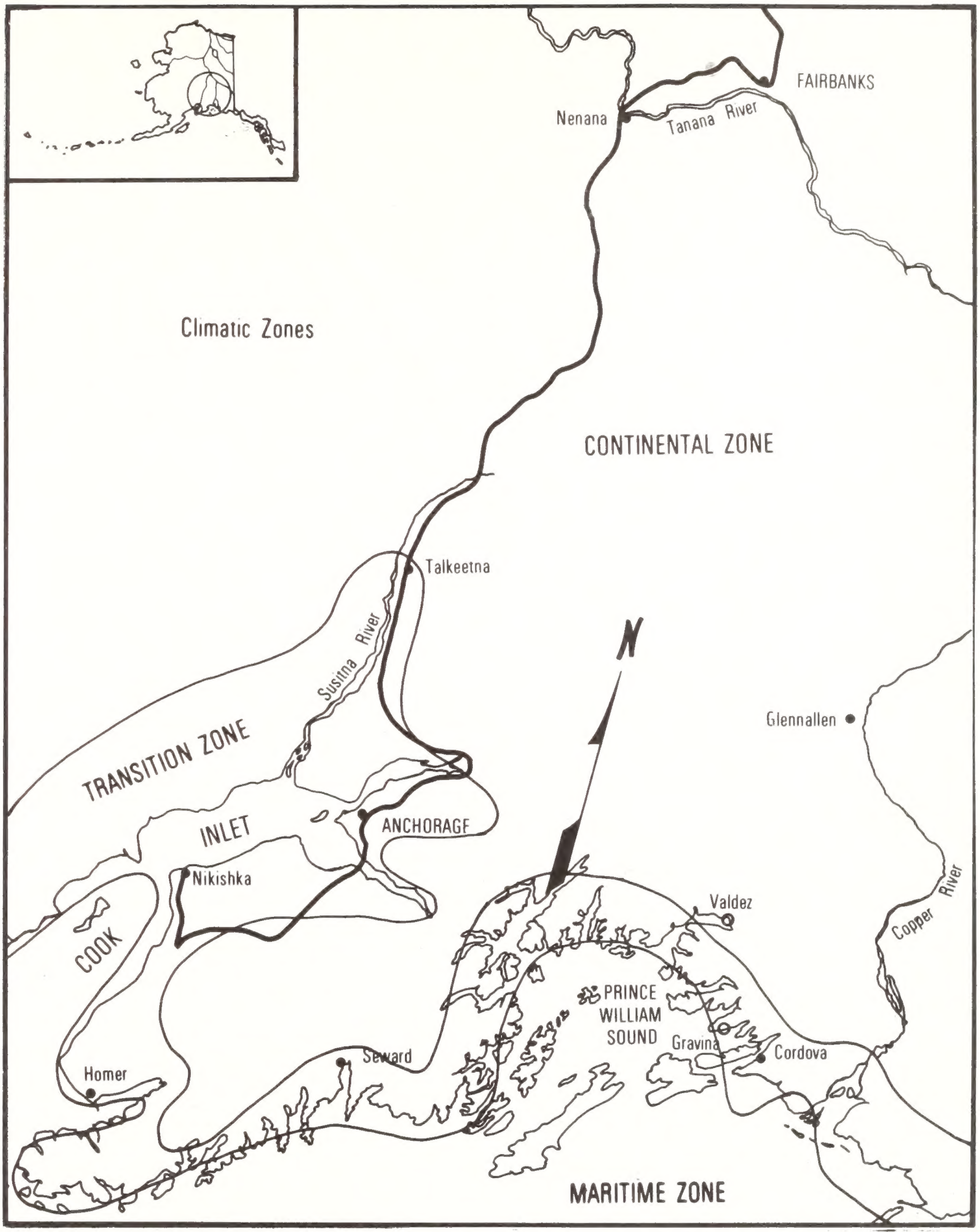


Figure 8.2.2-1 Climate - climatic zones

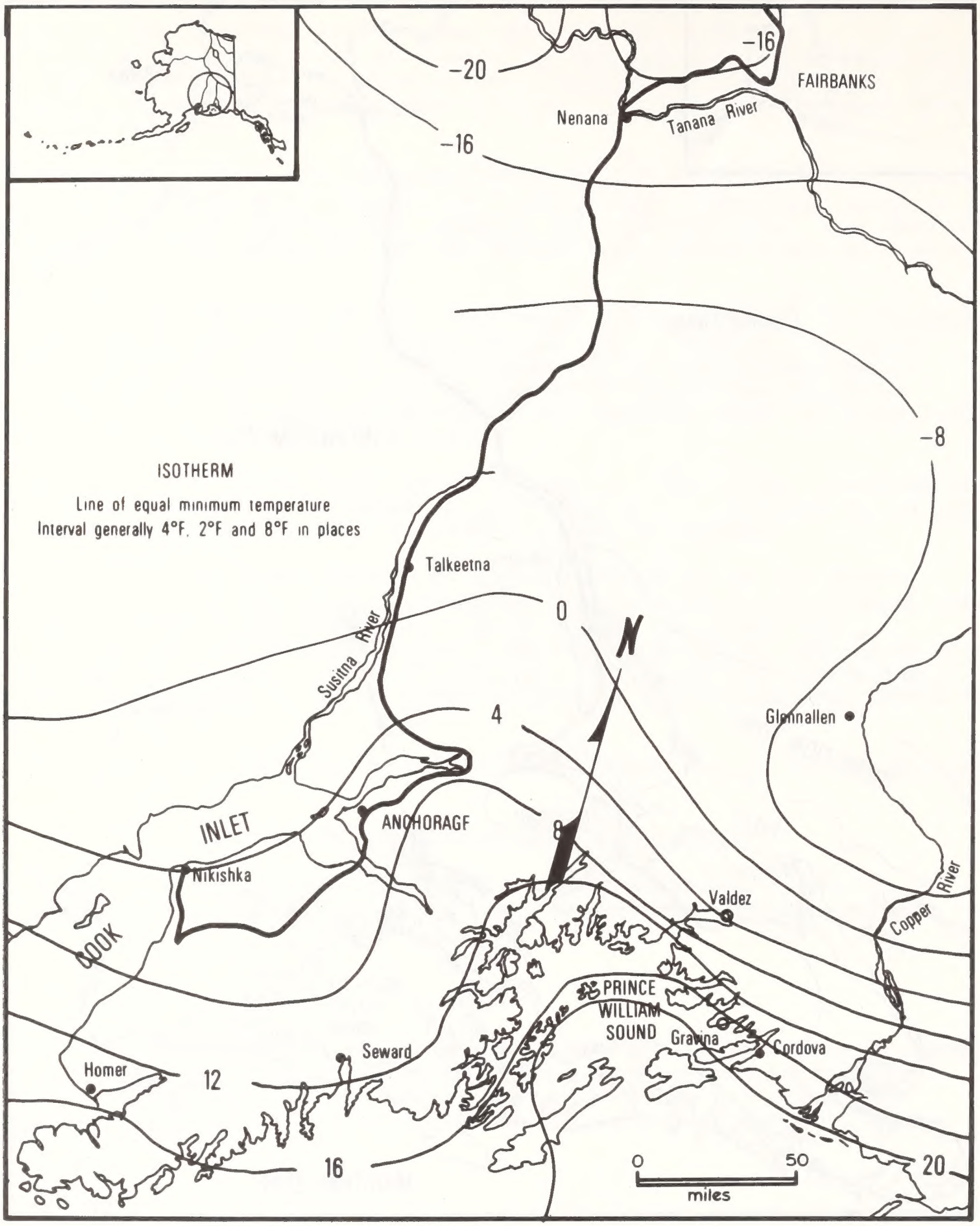


Figure 8.2.2-2 Climate - mean January minimum temperature °F

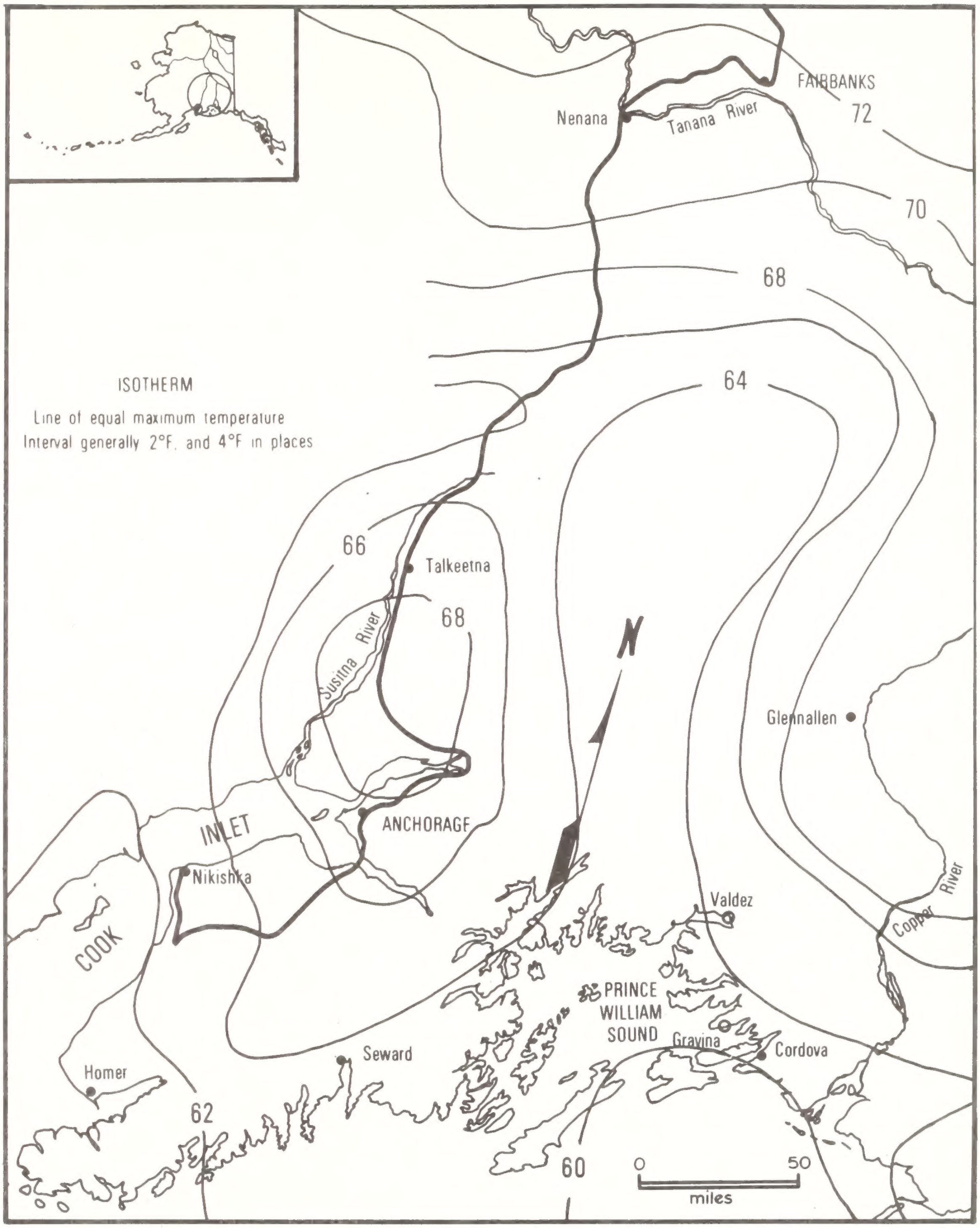


Figure 8.2.2-3 Climate - mean July maximum temperatures °F

Precipitation

Precipitation in the area north of the Alaska Range has an annual range of from about 8 to nearly 24 inches per year while south of the Alaska Range the average annual precipitation is from 12 to 24 inches per year at lower elevations. Refer to Figure 8.2.2-4 for precipitation levels along the route.

Winds

In the area north of the Alaska Range winds are generally calm with high winds being recorded at less than 50 miles per hour. South of the Alaska Range winds are generally calm although wind in excess of 50 miles per hour have been noted at several places along the route.

Micrometerological Conditions

In the area north of the Alaska Range ice fogs and other fog conditions as well as blowing snow would cause hazardous conditions along portions of the route at certain times of the year. South of the Alaska Range ice fogs are less common and less persistent. Blowing snow and severe wind conditions in some of the passes through the Alaska Range can constitute hazards at certain times of the year, especially in late winter.

Topography

Between Fairbanks and Nikiski, the Cook Inlet alternative passes through 7 physiographic provinces, as listed in Table 8.2.2-1 and shown on the map in Figure 8.2.2-5. Table 8.2.2-1 also shows where the description of these provinces may be found.

Broad Pass Depression

The Broad Pass Depression, 1,000-2,500 feet in altitude and 5 miles wide, is a trough having a glaciated floor; it opens on the east to a broad glaciated lowland with rolling morainal topography and central outwash flats. The bounding mountain walls of the trough are several thousand feet high. Long, narrow drumlinlike hills on the floor of the trough trend parallel to its axis, and the main streams in the trough are incised in rock-walled gorges a few hundred feet deep. The trough opens on its south end to the Cook Inlet-Susitna Lowland.

The divide between the Bering Sea and Pacific Ocean drainages crosses this depression in two places and is marked by nearly imperceptible passes. The southwestern part drains by the Chulitna River to the Susitna River; the central part, by the Nenana River north to the Yukon River; and eastern part, by the headwaters of the Susitna. Most streams head in glaciers in the surrounding mountains and are swift, turbid, and braided.

Many long, narrow lakes lie in morainal depressions in the central parts of the trough. Morainal and thaw lakes are common in the eastern part.

There are no glaciers. Most of the depression is underlain by permafrost.

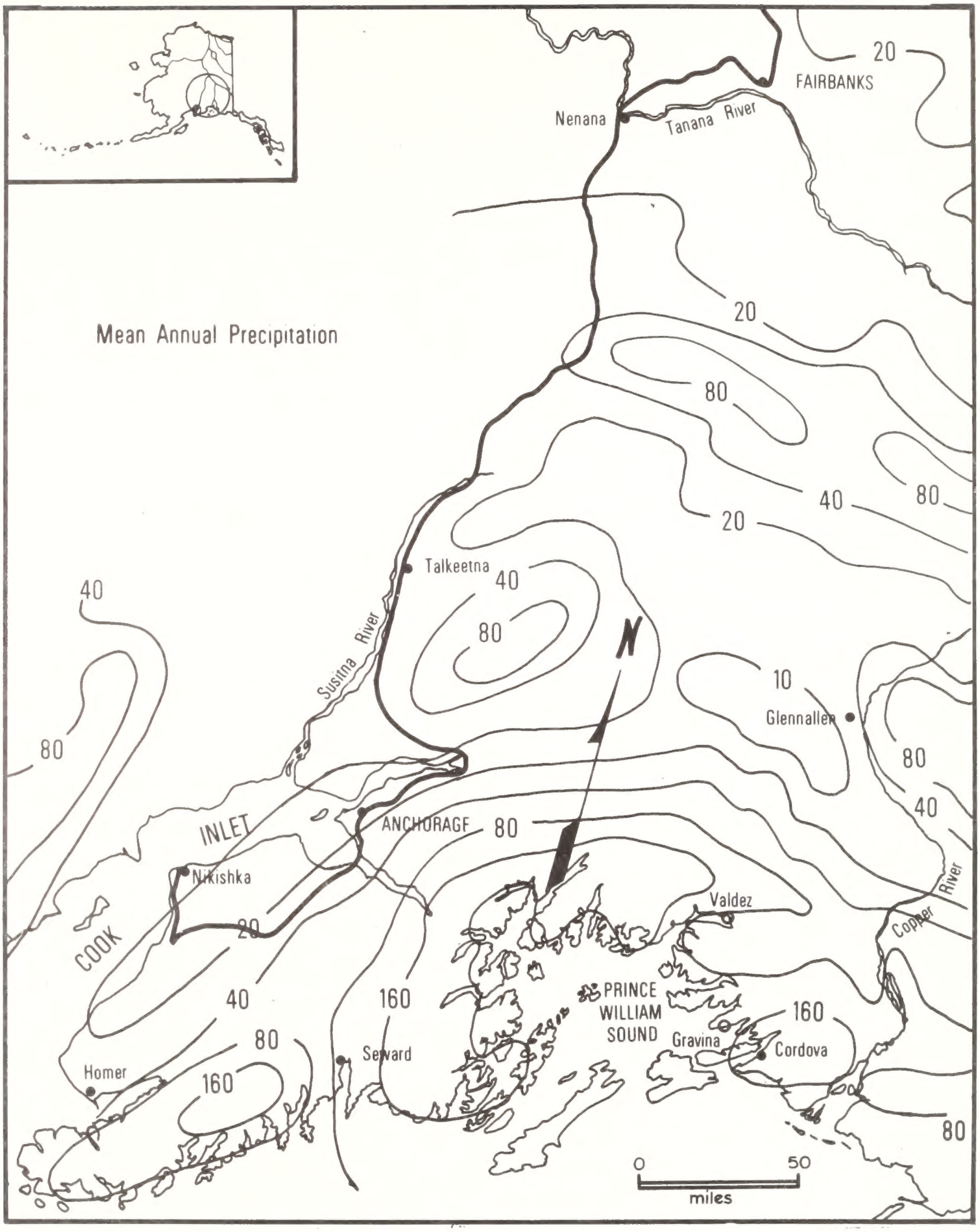


Figure 8.2.2-4 Climate - mean annual precipitation

Table 8.2.2-1 Physiographic provinces

Province	Location of Description
Yukon-Tanana Upland	8.2.1
Tanana-Kuskokwim Lowland	8.2.1
Northern Foothills	8.2.1
Alaska Range	8.2.1
Broad Pass Depressi	this section
Cook Inlet-Susitna Lowland	this section
Kenai-Chugach Mountains	8.2.1

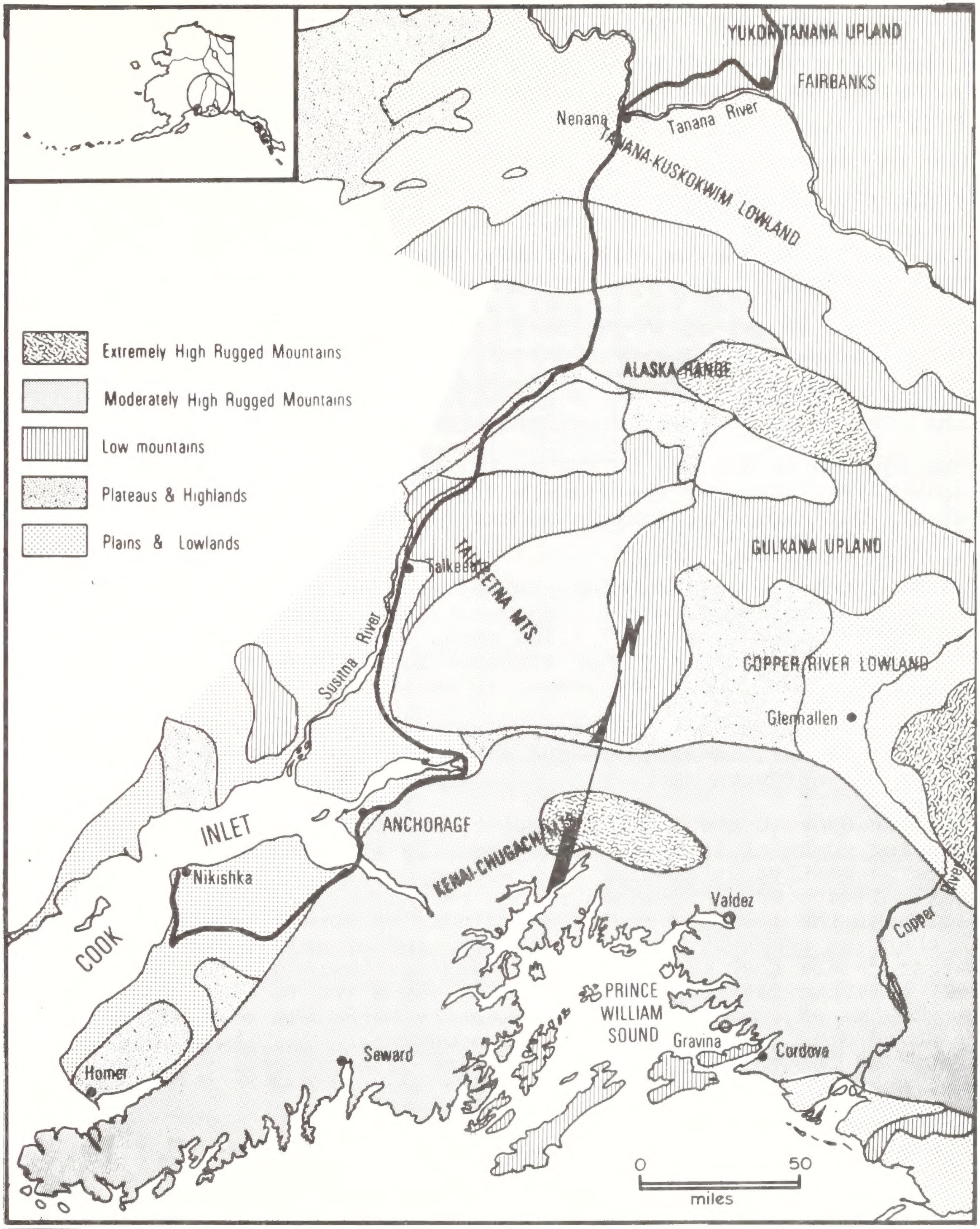


Figure 8.2.2-5 Physiography

Patches of poorly consolidated Tertiary coal-bearing rocks, in fault contact with older rocks of the surrounding mountains, show that this depression marks a graben of Tertiary age. Most of the bedrock consists of highly deformed slightly metamorphosed Paleozoic and Mesozoic rocks that are also exposed in the surrounding mountains. Ground moraine mantles the lowland.

Cook Inlet-Susitna Lowland

The Cook Inlet-Susitna Lowland is a glaciated lowland containing areas of ground moraine and stagnant ice topography, drumlin fields, eskers, and outwash plains. Most of the lowland is less than 500 feet above sea level and has a local relief of 50-250 feet. Rolling upland areas near the bordering mountain ranges rise to about 3,000 feet in altitide, and isolated mountains as high as 4,800 feet rise from the central part of the lowland. The Cook Inlet-Susitna Lowland is the major population center of Alaska and contains most of the developed agricultural land.

The lowland is drained by the Susita River and other streams that flow into Cook Inlet. Most of these streams head in glaciers in the surrounding mountains. The shores of Cook Inlet are for the most part gently curving steep bluffs 50-250 feet high.

Three large lakes--Tustumena, Skilak, and Beluga--fill ice carved basins at the margins of surrounding mountains. Lake Tustumena, the largest, is 23 miles long and 7 miles wide. Hundreds of small irregular lakes and ponds occur in areas of stagnant ice topography and on ground moraines. Stringbog ponds are common in marshes.

The section is almost ice-free, although one glacier reaches the lowland from the Alaska Range on the west, and sporadic permafrost is present in the northern part.

Bedrock beneath the lowland consists mainly of poorly consolidated coal-bearing rocks of Tertiary age, generally mildly deformed or flat lying; this rock is mantled by glacial moraine and outwash and marine and lake deposits. Sequences of moraines record sucessive glacial advances. The boundaries of the lowlands are of two kinds: a) abrupt straight mountain fronts that are probably faultline scarps, and b) uplands of hard preTertiary rocks that slope gently toward the lowland. The uplands are probably uplifted parts of the surface on which the Tertiary rocks were deposited; the edge of the lowland generally marks the edge of the Tertiary cover, which dips gently away from the mountains. The isolated mountains in the center of the lowland generally consist of metamorphic and granitic rocks of Mesozoic age.

Geology

Mineral Resources

Petroleum--The terminus of this alternative route would be within the producing Swanson River oil and gas field. The potential for discovering additional energy resources in the Broad Pass and Cook Inlet area is good to high. The route crosses three sedimentary basins where additional energy potential may be realized. Refer to Figure 8.2.2-6.

Coal--Large deposits of sub-bituminous and lignite coals occur both north and south of the Alaska Range (Figure 8.2.2-7) particularly along the west side of Cook Inlet and to a lesser extent on the east side.

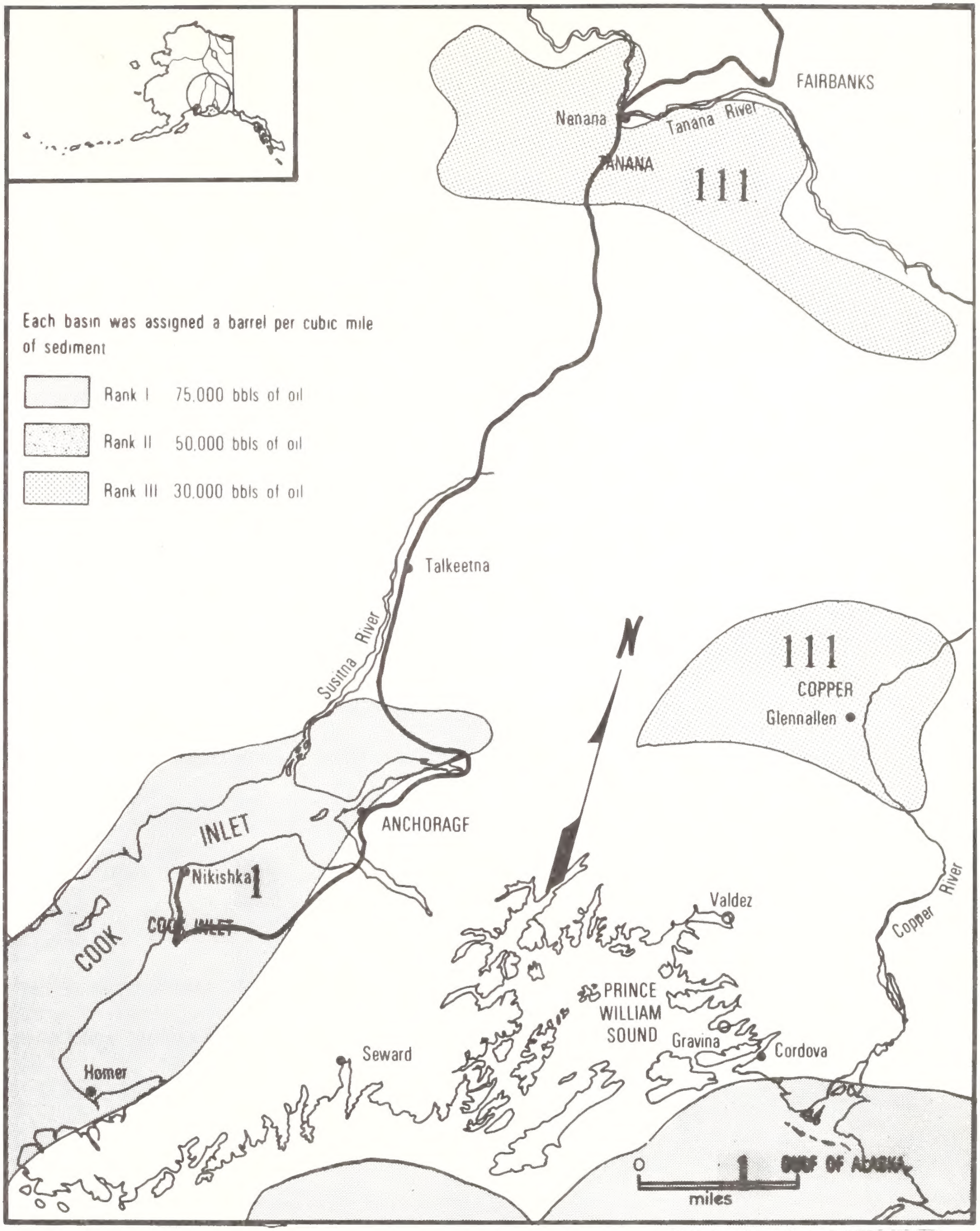


Figure 8.2.2-6 Petroleum

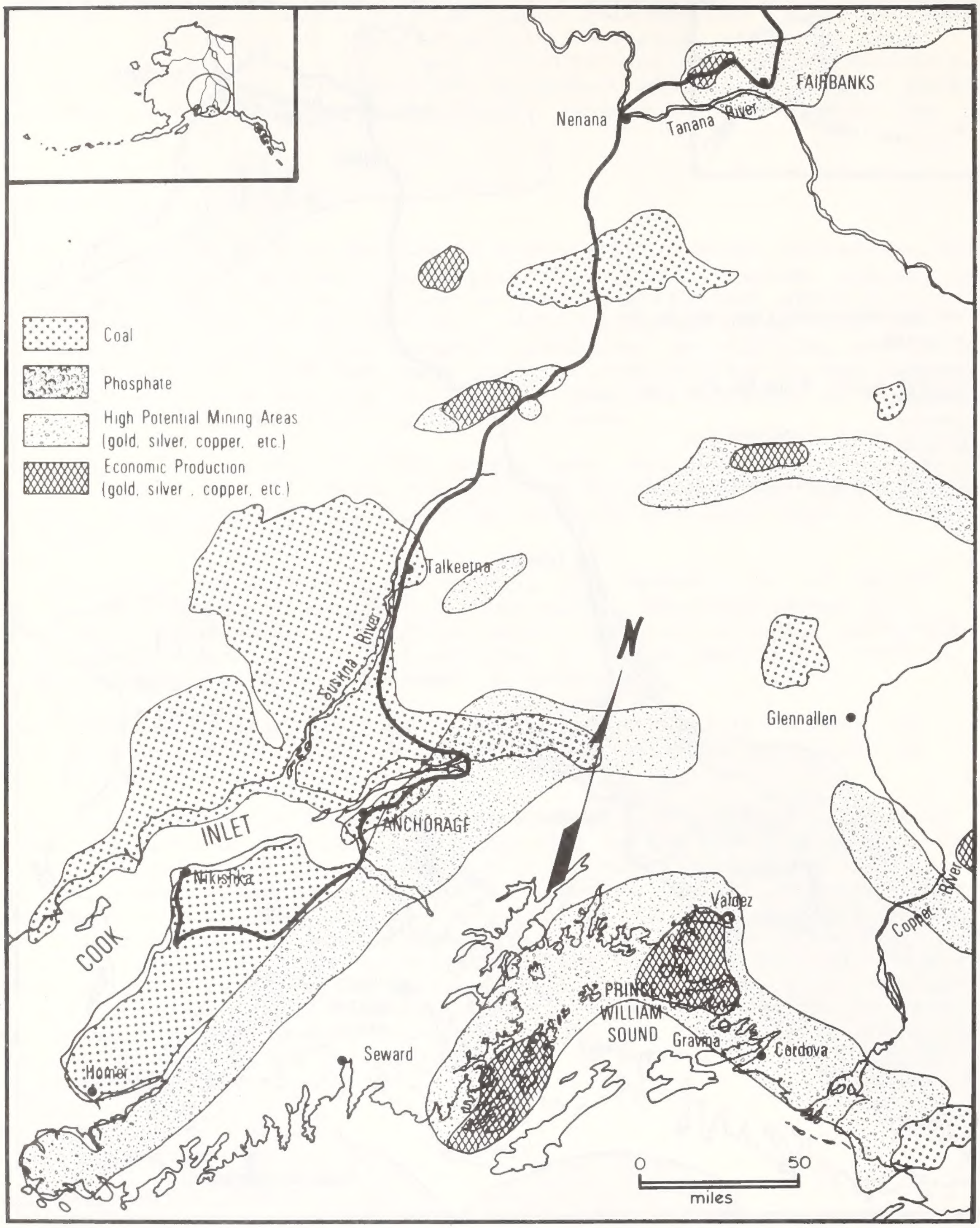


Figure 8.2.2-7 Minerals

Approximately 9,833 million tons of coal exists along this pipeline route and the alternatives.

The only coal mine operation currently active in Alaska is at Healy along this route. Prior to discovery of Cook Inlet oil and gas supplies, large amounts of coal for the Anchorage area were mined near Palmer.

Minerals--The route traverses numerous mineralized zones. While the route taps little "new country," potential for additional discoveries of gold, copper, zinc, and lead along the route are fair. Refer to Figure 8.2.2-7.

Stratigraphy and/or Lithology

Except where it crosses the Alaska Range, bedrock underlying the Cook Inlet route is generally overlain by surficial deposits. Bedrock underlying the route consists chiefly of schist, claystone, siltstone, sandstone, conglomerate, shale, slate, argillite, graywacke, greenstone, and andesite. The sedimentary rocks vary from poorly to well indurated, thinly bedded to massive, and have joint systems with spacing of from a few inches to several feet. Refer to Figure 8.2.2-8.

Surficial deposits underlying the corridor are extremely varied. From the Chatanika River to Dunbar, the route is underlain by locally ice-rich silt, sand, gravel, and colluvium. From Dunbar to Clear, the unconsolidated sediments consist of river silt, sand and gravel, dune sand, and swamp deposits.

From Clear through the Alaska Range to Talkeetna, the route is underlain by glacial outwash gravel, glacial morainal debris, glacial clay and silt, and river silt, sand, and gravel.

The segment of the Cook Inlet route from Talkeetna to the Knik River is underlain by glacial debris consisting of ground moraine, ground moraine modified by outwash, flood plain silt, sand and gravel and by swamps and lakes.

Permafrost

In the initial 56 miles from Fairbanks through the Tanana Highlands continuous permafrost is encountered. Tanana valley bottomlands contain isolated ice masses in silty alluvium. Through the Alaska Range, including foothills both north and south, intermittent permafrost is encountered on north aspects and in lowlands. The Susitna River valley is basically permafrost-free but frozen soil may be encountered in isolated locations under muskeg in lowlands. From Knik Arm to Nikiski the route is permafrost-free.

Refer to Figure 8.2.2-9 for permafrost and glacial areas along the route.

Seismicity

The seismic history along the corridor is short relative to the time over which strains accumulate to produce an earthquake, hence the historic record of seismicity is a limited guide to future seismic risk. Earthquakes of magnitude 6 and larger are potentially destructive, and earthquakes of magnitude 5 may even cause local damage. The seismic history for mainland

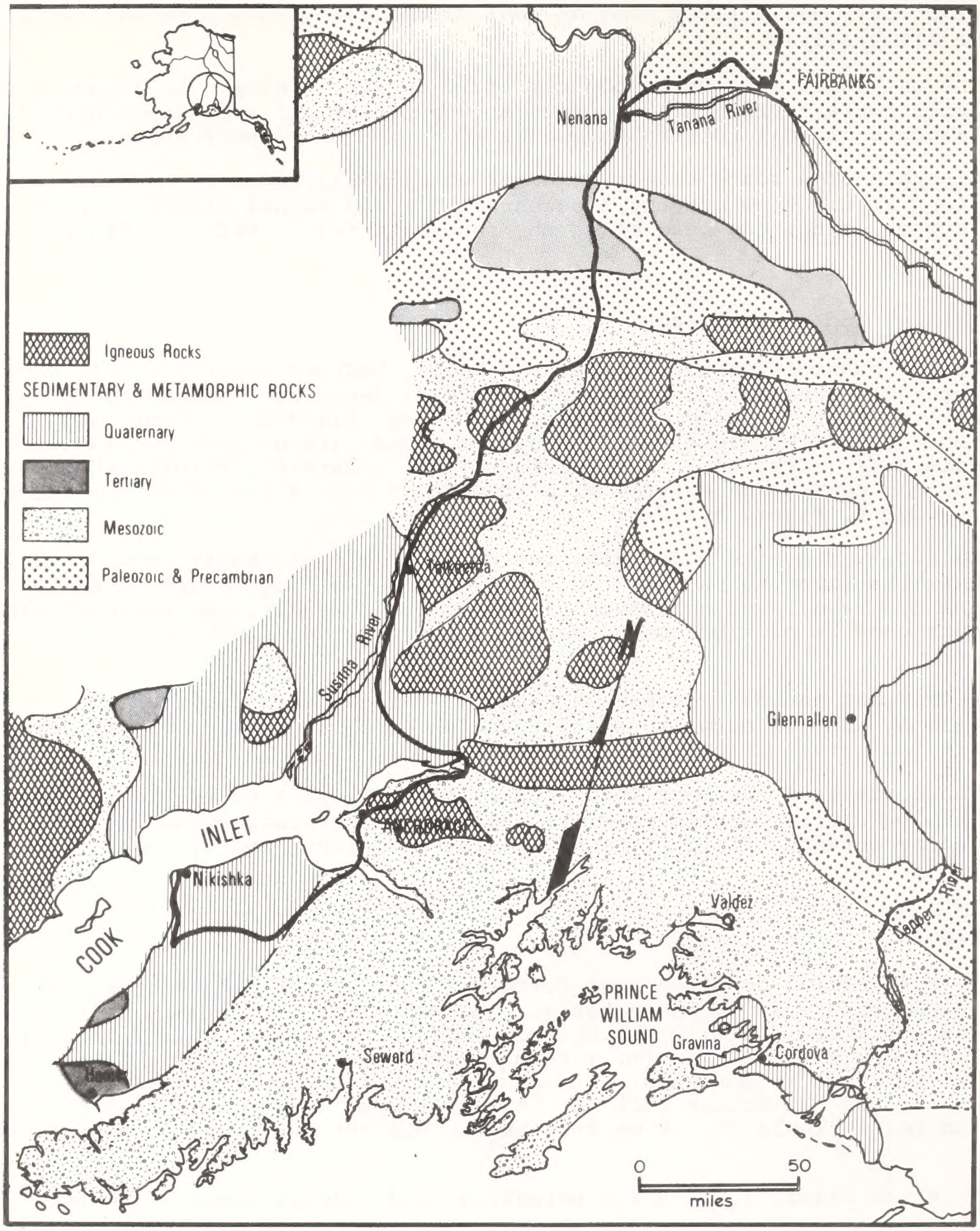


Figure 8.2.2-8 Geology

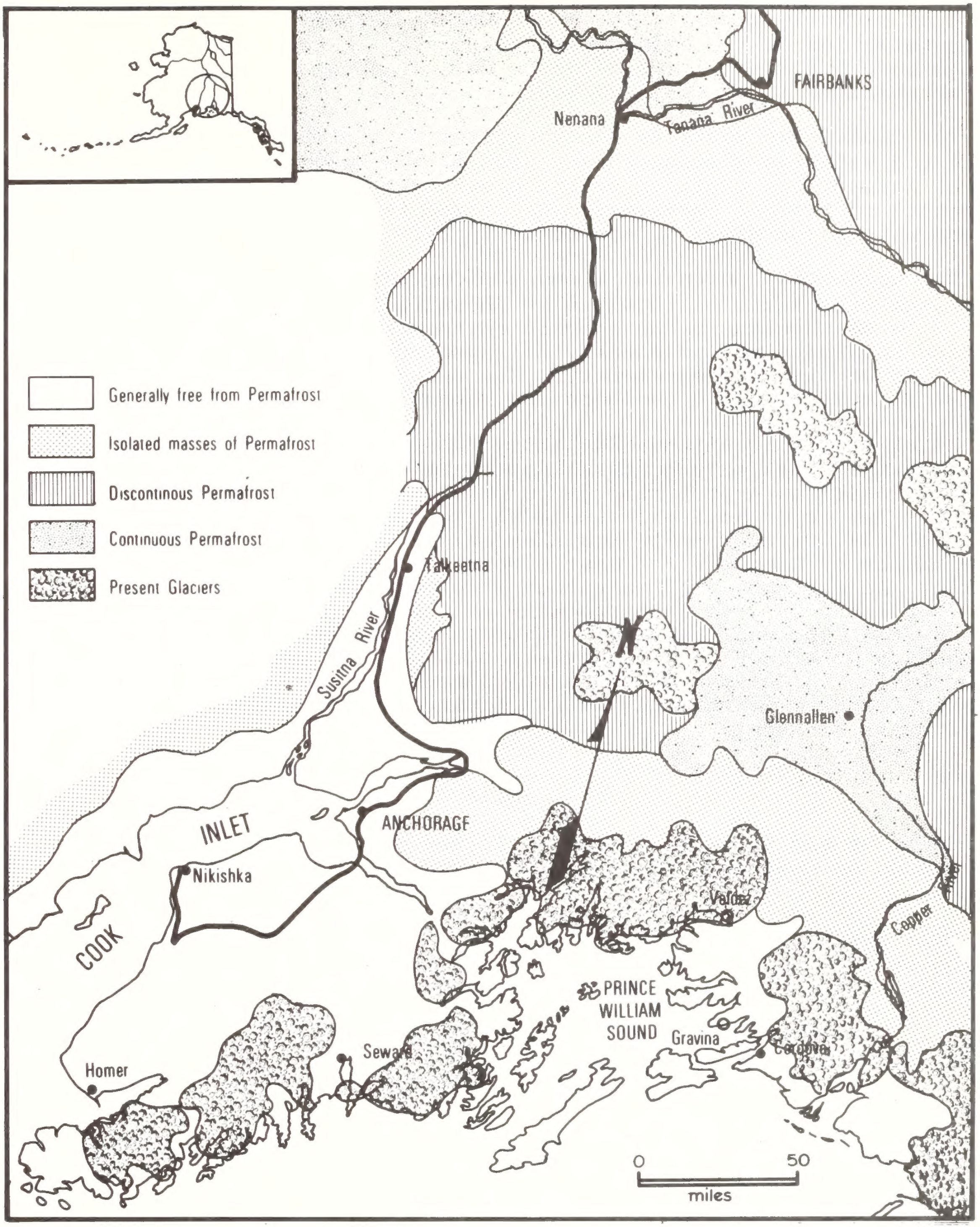


Figure 8.2.2-9 Glaciers and permafrost

Alaska is probably complete for earthquakes as small as magnitude 6.0 since the installation of the seismograph station at College in 1935 and as small as magnitude 5.0 since the mid-1960's when regional seismograph networks were established in central and southern Alaska.

The Cook Inlet route is characterized by a high level of seismicity associated with the northeast extension of the Aleutian seismic belt into central Alaska. In addition to the great 1964 earthquake (magnitude 8.5), epicenters of several shallow shocks of magnitude 7.0 and larger have been located within 100 miles of the route in this century.

The earthquake potential along the corridor may be specified in terms of maximum expectable earthquakes as shown in Table 8.2.2-2. The maximum expectable earthquake is the largest earthquake that on the basis of existing knowledge may reasonably be expected to occur; it exceeds the largest known historic earthquake. The zonation of the route might be refined if more complete geologic and geophysical data were available.

Focal depths of earthquakes along the corridor range from shallow depths in the crust to subcrustal depths in excess of 75 miles. There is no a priori reason to expect that large shallow shocks will not rupture the surface. Two major active faults with geologic evidence of Holocene offsets intersect the corridor - the McKinley strand of the Denali fault system in the vicinity of Cantwell and Castle Mountain fault in the vicinity of Houston. An earthquake of magnitude 8 accompanied by right lateral fault offset at least 20 feet is expectable on the McKinley strand of the Denali fault system, whereas the maximum expectable magnitude and total vertical and horizontal offset on the Castle Mountain fault are about 7.5 and 10 feet respectively. A delineation of earthquake epicenters (Gedney and others, 1972) indicates a seismically active fault that intersects the corridor in the vicinity of Healy.

Soils

Soils of the route are shown on Figure 8.2.2-10 and detailed information on physical conditions of these soils is provided in Table 8.2.2-3.

Well drained brown silty to gravelly soils without permafrost occupy rolling uplands and outwash plains from Fairbanks to the upper Susitna drainages at the divide of the Alaska Range. Soil units 5 & 6 are deep and loamy textured in the Tanana Highlands and shallow and gravelly in the valley from Nenana south through the Range to Broad Pass. Associated alluvial soils occupy sites along the Tanana River. Erosion potentials range from low on gravelly soils of low slopes to high on silt loams of the highlands.

The most extensive upland soil of the Susitna Valley from Cantwell to Willow Creek is a well drained loamy acid soil of units 10-12 occupying low sloping sites, moraines and hills. Erosion potential is moderate on low slopes and high on steeper sites.

Soils of the route from Willow to the Nikiski Site are shallow to moderately deep gravelly loam of units 10, 11, and 2, with texture variations to silt loam. The erosion potential is high. Peat deposits occupy depressions in all segments of these routes from the Alaska Range to the port site.

The port site of Nikiski is located on moderately deep loamy upland soils with moderate to high potential for erosion.

Table 8.2.2-2 Maximum expectable earthquakes

Segment	Magnitude
Fairbanks to Rex	7.5
Rex to Broad Pass	8.0
Broad Pass to Palmer	7.5
Palmer to Nikiski	8.5

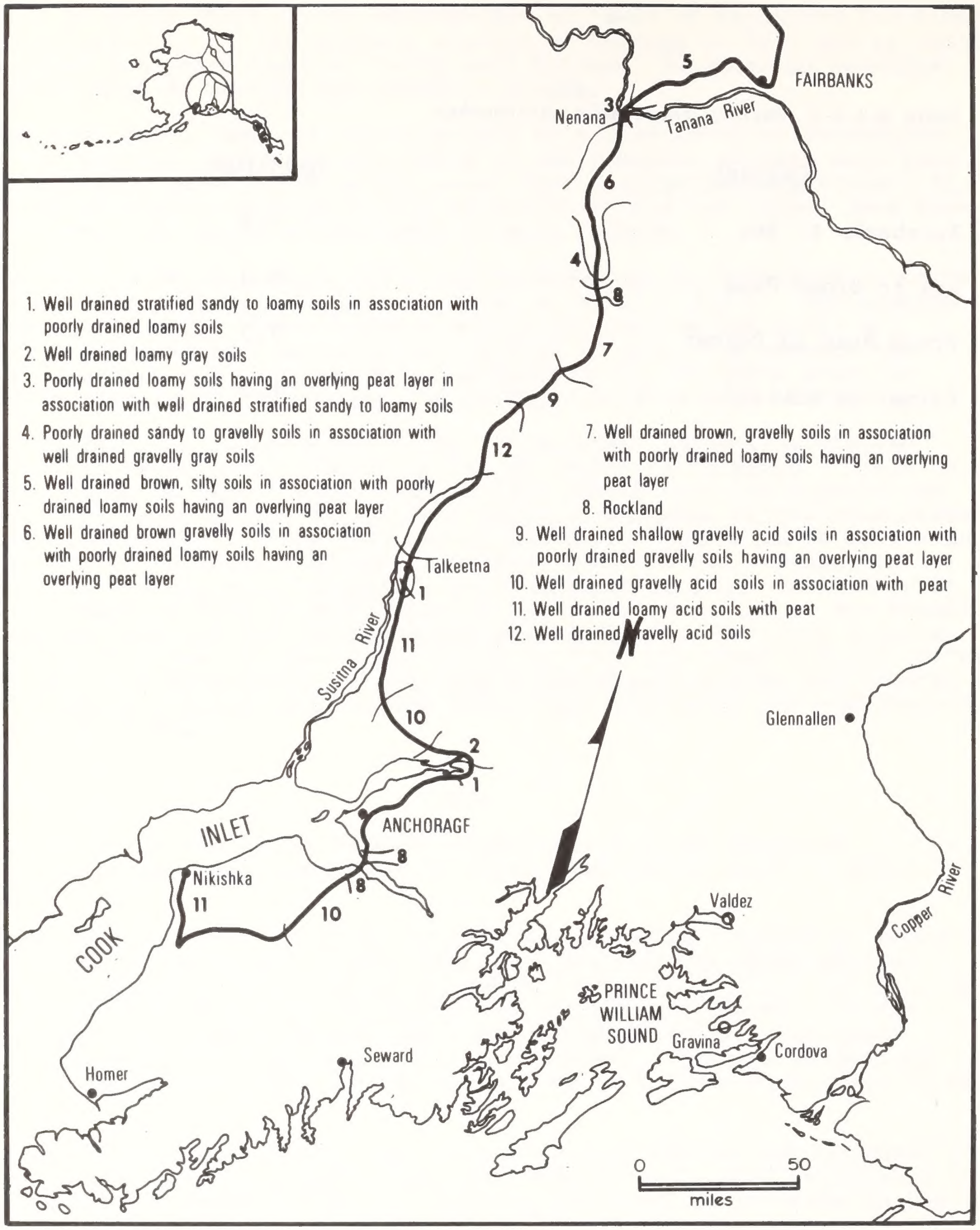

1. Well drained stratified sandy to loamy soils in association with poorly drained loamy soils
2. Well drained loamy gray soils
3. Poorly drained loamy soils having an overlying peat layer in association with well drained stratified sandy to loamy soils
4. Poorly drained sandy to gravelly soils in association with well drained gravelly gray soils
5. Well drained brown, silty soils in association with poorly drained loamy soils having an overlying peat layer
6. Well drained brown gravelly soils in association with poorly drained loamy soils having an overlying peat layer
7. Well drained brown, gravelly soils in association with poorly drained loamy soils having an overlying peat layer
8. Rockland
9. Well drained shallow gravelly acid soils in association with poorly drained gravelly soils having an overlying peat layer
10. Well drained gravelly acid soils in association with peat
11. Well drained loamy acid soils with peat
12. Well drained gravelly acid soils
FAIRBANKS
5
3
Nenana
Tanana River
6
4
8
7
9
12
Talkeetna
1
Susitna River
11
10
2
1
Glennallen
INLET
ANCHORAGE
8
18
Nikishka
11
10
COOK
Valdez
Copper River
PRINCE WILLIAM SOUND
Gravina
Cordova
Seward
Homer
0
50
miles

Figure 8.2.2-10 Soils

Table 8.2.2-3 Soils - Cook Inlet route

Map No.	Description	Miles	Percent	Location
1	Well drained stratified sandy to loamy soils in association w/poorly drained loamy soils	18	4.2	Talkeetna and Knik Rivers
2	Well drained loamy gray soils	11	2.6	Wasilla-Matanuska Valley
3	Poorly drained loamy soils having an overlying peat layer in association w/well drained stratified sandy to loamy soils	5	1.1	Nenana
4	Poorly drined sandy to gravelly soils in association w/well drained gravelly gray soils	2	0.5	Healy
5	Well drained brown silty soils in association w/poorly drained loamy soils having an over-lying peat layer	56	13.2	Fairbanks to Nenana-Tanana Highlands
6	Well drained brown gravelly soils in association w/poorly drained loamy soils having an overlying peat layer	55	12.9	Lower Nenana River
7	Well drained brown gravelly soils in association w/poorly drained loamy soils having an overlying peat layer	32	7.5	Cantwell to McKinley Area
8	Rockland	6	1.1	Healy, Turn-again Arm
9	Well drained shallow gravelly acid soils in association w/poorly drained gravelly soils having an overlying peat layer	18	4.2	Broad Pass
10	Well drained gravelly acid soils in association w/peat	68	16.0	Susitna Valley, Anchorage and Kenai Peninsula
11	Well drained loamy acid soils in association w/peat	99	23.4	Kenai Peninsula
12	Well drained gravelly acid soils	55	13.2	Chulitna River Upper Susitna River
	Total	407	99.9	

Several soils of the line segment, extending from Fairbanks to Cook Inlet are described in detail by Rieger et al., 1959, Shoephoester, et al, 1968, and Shoephoester and Hinton, 1973.

Water Resources

Surface Water

Two major river basins are traversed by the Cook Inlet alternative route. North of the Alaska Range it is within the Tanana sub-basin of the Yukon basin. Major rivers crossed include the Tanana and the Nenana.

South of the Alaska Range the route is within the Susitna Basin all the way to Knik Arm. The Susitna River would be crossed several times.

Numerous smaller streams are crossed within the two basins. On the Kenai Peninsula the Swanson River is crossed, as are numerous smaller streams.

Streamflows data are available and have been published by the U.S. Geological Survey in cooperation with the State of Alaska on the Tanana River, Nenana River, Susitna River, and several tributaries to the Susitna River. To the south a considerable amount of data is available on streams on the Kenai Peninsula side of Cook Inlet. Little data is available on streams on the western side of the Inlet.

Streams on both sides of the Alaska Range show their first increased flow in late April which continues through May and the highest stream flows recorded are usually in June. Stream breakup usually precedes the snow melt and occurs in late April or early May. Streams usually remain at high levels throughout the summer and decline in early winter reaching lows in March or early April.

Quality of water in streams in the Fairbanks area is generally good. Most of the streams flowing north from the Alaska Range are high in sediment load and are especially high in load during early summer. Dissolved solids content of waters ranges generally from about 200 to 500 mg/l. Almost all waters are of the calcium bicarbonate type, alkaline, and are acceptable for most uses.

Water south of the Alaska Range is also mostly glacier fed and contains large amounts of sediment. Almost all of the waters are of the calcium bicarbonate type, alkaline, have a dissolved solids range of from 50 to 200 mg/l. and are acceptable for most uses.

Ground Water

Groundwater movement is generally controlled by structures in that most groundwater movement in the areas on both sides of the Alaska Range is down slope along the stream valley.

The principal aquifer that is tapped for water supplies is the alluvial and glacial aquifer system which parallels the major stream system in the area of the pipeline route.

Little data is available on the general recharge rates across the area.

Present Water Use

Groundwater is utilized as a water supply by individuals, businesses, and private residences between Fairbanks and Willow. Palmer has a municipal water supply from wells as does the city of Kenai on the Kenai Peninsula.

In the Greater Anchorage Area domestic water in excess of half the requirements are from surface waters of the Ship Creek drainage. Wells provide the remainder of the Anchorage supply and tap an aquifer believed to be associated with the Campbell Creek watershed.

Hydrological Hazards

Icing, as defined in previous section is not a problem on this route. Until 1964 Lake George, in the Knik River drainage, annually broke through the glacial dam that created the lake. This occurrence was always accompanied with major flooding in lower reaches. The phenomenon has not recurred since the 1964 earthquake and the glacier now appears to be receding.

Vegetation

Vegetative Types

Five vegetative types are crossed in the 425 miles from Fairbanks to Nikiski. Approximate percentage of each is listed in Table 8.2.2-4.

All types have been previously described in Section 8.2.1, Description of the Environment. Refer to Figure 8.2.2-11 for a generalized ecosystem map encompassing this alternative route.

Human Influence on Existing Vegetation

Human influence on vegetation along the Cook Inlet route is similar to, but more intensive than described for the Delta Junction to Gravina Point alternative (Section 8.2.1, Description of the Environment). Both routes are along existing transportion corridors with associated human use and occupancy. The route exhibits more intensive human influence since it passes through the most heavily populated portion of the state. Almost half of Alaska's population lives within 25 miles of Anchorage.

In Fairbanks the human influence on vegetation is similar to that of Anchorage or any other urban area.

Threatened Species

There are no known species whose existence is threatened by this project.

Fire Hazards

Fire hazards along this route are similar to those discussed in 8.2.1, Description of the Environment, with two significant exceptions. Since this route passes near the major population centers of Alaska, the incidence of man-caused fire is disproportionally higher than the state averages.

Table 8.2.2-4 Vegetative types

Type	Approx.% of Routes
Alpine Tundra	7
High Brush	4
Lowland spruce hardwood	39
Bottomland spruces-popular	15
Upland spruce-hardwood	35
	100 %

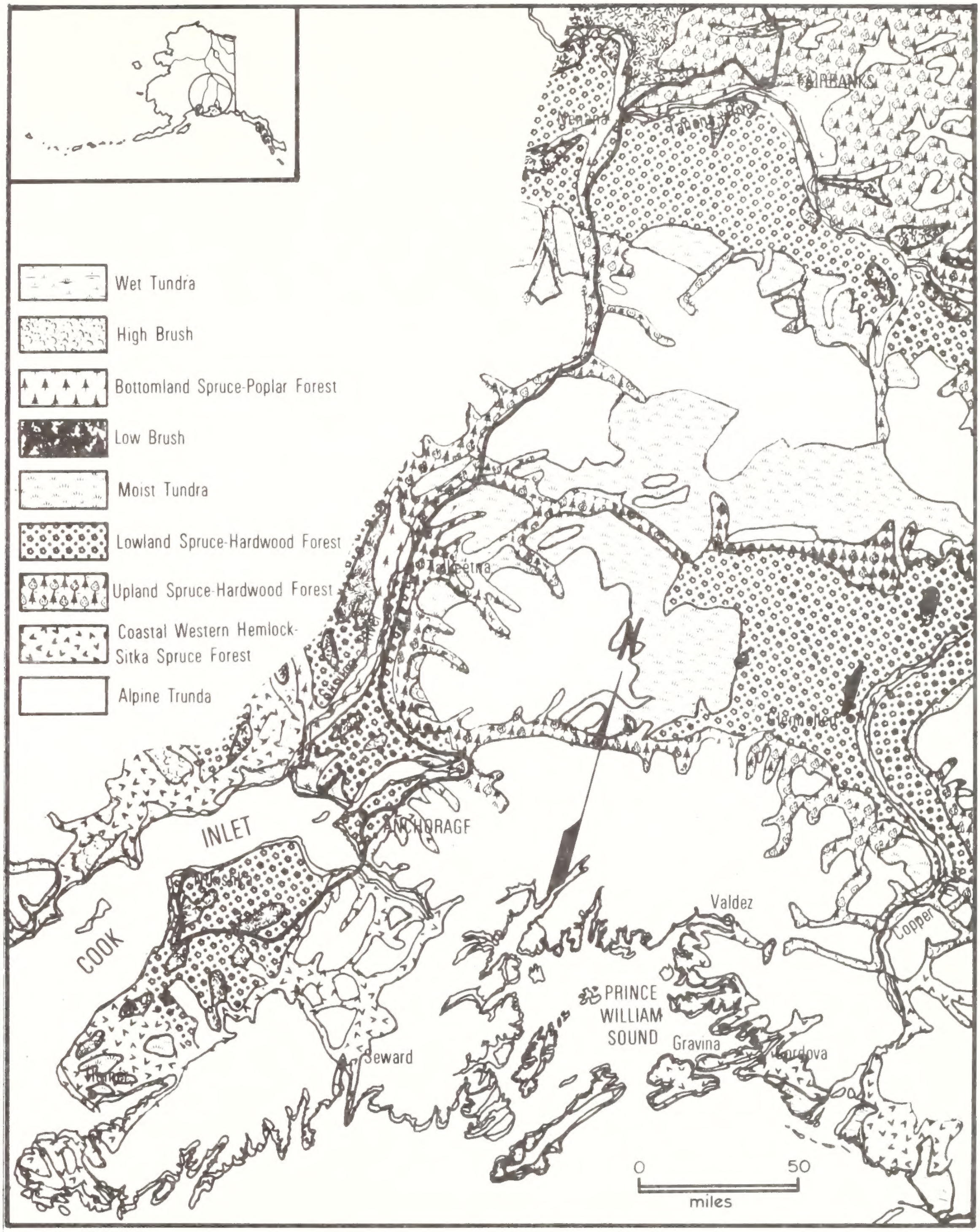


Figure 8.2.2-11 Generalized land ecosystems

Secondly, the Kenai Peninsula area, because of heavy recreational use, is in certain years very susceptible to fire. Several major fires since 1906 have burned hundreds of thousands of acres. This area is not as fire resistant as the coastal forest around Point Gravina.

Although all vegetation zones crossed by the proposed pipeline route are subject to fire, they differ in their ability to carry a fire once it has begun as shown in Table 8.2.2-5.

Man caused fire potential exists mainly during the period of May through September. The exception will be the deep burning winter camp, warming, or other fires that reach peat beds of sufficient mass to sustain fires through winter months. These fires will burn to the surface and ignite surface fuels during the summer months.

Potential for man caused fires would increase as the route moves from the moist coastal tundra to the lowland spruce and Alpine tundra. This is consistent with fire's rate of spread in these fuels.

Lightning occurs during the period June through August and can cause fires on and adjacent to all proposed alternative routes.

Wildlife

Wildlife populations and distributions are very similar to those encountered along the Gravina Point Alternative route (Section 8.2.1, Description of the Environment).

Land Animals

Wildlife species through the Alaska Range are abundant in variety and number. Figure 8.2.2-12 shows sensitive wildlife habitat areas. Figure 8.2.2-13 shows location of caribou herds.

There are over 130 varieties of birds and 37 kinds of mammals such as caribou, Dall sheep, moose, wolf, wolverine, beaver, Canadian lynx, red foxes, and a considerable number of grizzlies. In addition, other species present are black bear, marmot, pika, and snowshoe hare, all of which can be observed along the route.

In the Susitna River basin game populations are also quite varied. Moose, black and brown bears are present. Segments of the Nelchina caribou herd periodically range eastward to the route. Beaver, present in sloughs along the river, are the most abundant furbearers. Other species of fur animals present include land otter, mink and fox. Wolves occasionally travel through the area. Other fur bearers that occur there are lynx, marten, wolverine and muskrat.

The Kenai Peninsula, primarly noted for the large moose of the Kenai National Moose Range, also supports a mixed animal population similar to that of the Susitna basin. Interestingly, caribou occurred on the Kenai Peninsula until the early 1900's. Apparently loss of habitat, due to extensive fires, and intensive hunting around the turn of the century caused the herd to decline rapidly and it became extinct about 1913 (Hemming, 1971).

In the early 1950's the U.S. Fish and Wildlife Service conducted feasibility studies to determine if historic caribou ranges on the Kenai Peninsula would again support caribou (Alaska Game Commission, 1952).

Table 8.2.2-5 Fire potential

Vegetative Type	% by Type	Rate of Spread	Resistance to Control
Upland Spruce & Hardwood	50	High	Medium
Lowland Spruce & Hardwood	25	High	High
Moist tundra	6	Medium	Medium
Bottomland Spruce & Popular	6	Medium	High
Alpine Tundra	13	High	Low

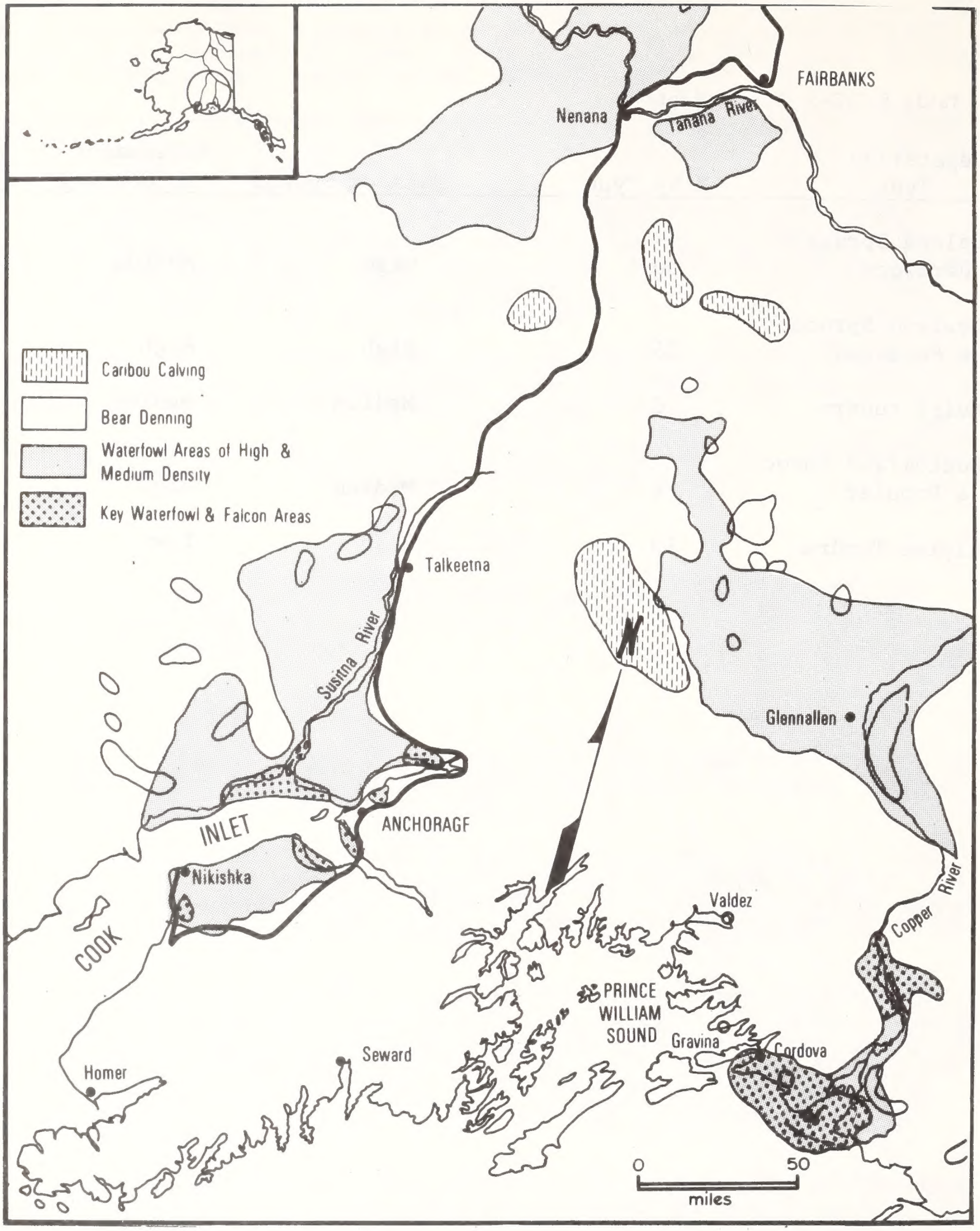


Figure 8.2.2-12 Sensitive wildlife habitat

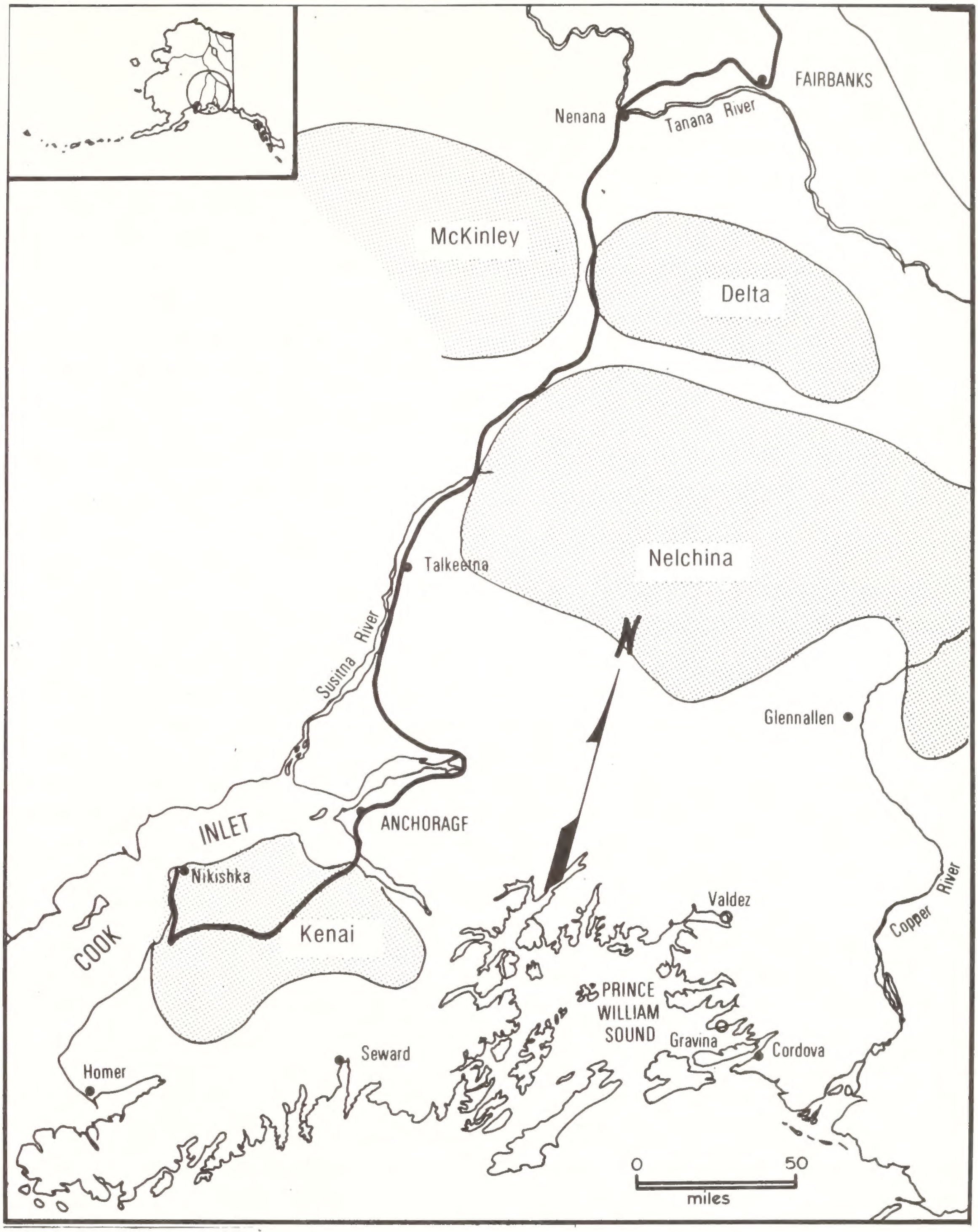


Figure 8.2.2-13 Main Caribou herds of Alaska

Suitable range was found in the Chickaloon River-Mystery Creek area, the Skilak-Tustumena Lake area and the Caribou Hills north of Homer. These areas were reappraised in 1964 by the Alaska Department of Fish and Game and the U.S. Fish and Wildlife Service.

In May 1965, 15 caribou were released near the Chickaloon River and in April 1966, 29 more were released at Watson Lake near Sterling. This transplant was highly successful and since 1966 caribou have been observed at scattered points over the entire western half of the Kenai Peninsula.

At the present time the largest group, containing about 120 animals, occurs in the mountains south of Hope, between the headwaters of Resurrection Creek and the Chickaloon River. Smaller bands are present on the lowlands just north of Kenai Airport on the Moose River Flats, and near Indian Creek just east of Tustumena Lake. Based on population growth rates of other Alaskan caribou herds, the Kenai herd should contain at least 200 caribou by 1972.

Refer to Figure 8.2.2-13 which shows that the route will follow a natural corridor between 3 herds in the Alaska Range but passes through the range of the Kenai herd.

Birds

Table 8.2.2-6 lists the 146 bird species regularly (seasonally or permanent) seen in the Cook Inlet area, including the Susitna Basin (USFWS, 1968).

The route will traverse waterfowl breeding and nesting areas along the Susitna River, Potter Marsh outside Anchorage and in portions of Kenai National Moose Range.

Other waterfowl habitat traversed includes the Tanana and Nenana River flats. In the Fort Hamlin Hills area the route would come within 10 miles of the proposed Yukon Flats National Wildlife Refuge.

Fish

The principal fresh-water sport fish present in the Susitna Basin are rainbow and lake trout, Dolly Varden and grayling. Other species of lesser importance are burbot, sucker, sculpin, and two species each of stickleback and whitefish.

Chinook, sockeye, pink, chum, and coho salmon are found in varying abundance in major tributaries of the Susitna River and other streams which enter Cook Inlet. During the past 10 years, the first wholesale value of the Cook Inlet salmon case pack has averaged over $7,300,000 annually. Of this, the Susitna River system is estimated to produce annually 38 percent or about $2,774,000.

Eulachon spawn in the early spring in several of the rivers on the east side of Cook Inlet, notably the Twenty Miles and Kenai Rivers, and provide sport-subsistence fishing opportunities at that time.

A major sport fishery has developed for the chinook, coho and sockeye salmon during June, July and August in many of the stream's tributaries to Cook Inlet. Those flowing into the Susitna River from the east such as the Little Susitna River, Willow, Kantishna, and Montana Creeks, would be crossed by this pipeline right-of-way.

Table 8.2.2-6 Birds of the Cook Inlet basin

*Common Loon
*Arctic Loon
Red-throated Loon
*Red-necked Greve
*Horned Greve
*Double-crested Cormorant
Whistling Swan
*Trumpeter Swan
*Canada Goose
Black Brant
White-fronted Goose
Snow Goose
*Mallard
Gadwall
*Pintail
*Green-winged Teal
*American Widgeon
*Shoveler
Canvasback
*Greater Seaup
Common Goldeneye
*Barrow's Goldeneye
Bufflehead
Oldsquaw
*Harlequin Duck
Common Eider
White-winged Scoter
Surf Scoter
Common Scoter
*Common Merganser
*Slate-colored Junco
*Tree Sparrow
*White-crowned Sparrow
*Golden-crowned Sparrow
*Fox Sparrow
*Lincoln's Sparrow
*Song Sparrow
Lapland Longspur
*Snow Bunting
*Northern Waterthrush
*Wilson's Warbler
*Rusty Blackbird
*Pine Grosbeak
*Gray-crowned Rosy Finch
*Common Redpoll
*Pine Siskin
White-winged Crossbill
*Savannah Sparrow
*Red-breasted Merganser
*Goshawk
*Sharp-shinned Hawk
*Red-tailed Hawk
*Harlan's Hawk
Rough-legged Hawk
*Golden Eagle
*Bald Eagle
*Marsh Hawk
*Osprey
Gyrfalcon
*Peregrine Falcon
*Pigeon Hawk
*Spruce Grouse
*Willow Ptarmigan
*Rock Ptarmigan
*White-tailed Ptarmigan
*Sandhill Crane
*Semipalmated Plover
Killdeer
American Golden Plover
Black-bellied Plover
Surf Bird
Ruddy Turnstone
Black Turnstone
*Common Snipe
Whimbrel
*Spotted Sandpiper
*Solitary Sandpiper
*Wandering Tattler
*Greater Yellowlegs
*Lesser Yellowlegs
Pectoral Sandpiper
Baird's Sandpiper
*Least Sandpiper
Dunlin
*Short-billed Dowitcher
Long-billed Dowitcher
Semipalmated Sandpiper
*Western Sandpiper
*Hudsonian Godwit
Sanderling
*Northern Phalarope
Parasitic Jaeger
*Long-tailed Jaeger
Glaucous Gull
*Glaucous-winged Gull
*Herring Gull
*Mew Gull
*Bonaparte's Gull
Black-legged Kittiwake
*Arctic Tern
Aleutian Tern
*Great Horned Owl
Snowy Owl
Hawk-Owl
Great Gray Owl
*Short-eared Owl
Boreal Owl
Saw-whet Owl
*Belted Kingfisher
*Yellow-shafted Flicker
*Hairy Woodpecker
*Downy Woodpecker
Black-backed Three-toed Woodpecker
*Northern Three-toed Woodpecker
*Say's Phoebe
*Traill's Flycatcher
*Western Wood Pewee
*Olive-sided flycatcher
*Horned Lark
*Violet-green Swallow
*Tree Swallow
*Bank Swallow
*Cliff Swallow
*Gray Jay
Steller's Jay
*Black-billed Magpie
*Common Raven
*Black-capped Chickadee
*Boreal Chickadee
*Brown Creeper
Dipper
*Robin
*Varied Thrush
*Hermit Thrush
*Swaison's Thrush
*Gray-cheeked Thrush
*Golden-crowned Kinglet
*Ruby-crowned Kinglet
*Water Pipit
*Bohemian Waxwing
Northern Shrike
*Orange-crowned Warbler
*Myrtle Warbler
*Townsend's Warbler
*Blackpoll Warbler

* Known to breed in the area.

Various species of both finfish and shellfish are important in the economy of Cook Inlet. Exploratory deepwater trawls conducted by the National Marine Fisheries Service, revealed the presence of 25 species of finfish, of which butter sole, yellowfin sole, turbot, and pollock were most abundant. They also recorded five species of shrimp, three species of crabs, octopus, scallops, and other invertebrates. Systematic inventories of pelagic species have not been made. The periods and extent of these exploratory trawls were not determined when preparing this statement.

Fish populations in Cook Inlet include anadromous species, such as the salmon and smelt; and resident species, such as flounders and sculpins. Other species, while not anadromous, may be considered migratory, coming into shallower water at certain times of the year. The halibut falls into this category.

All five North American species of Pacific salmon, the chinook sockeye, pink, coho, and chum inhabit Cook Inlet in numbers.

The most abundant of salmon has been determined to be pink, sockeye, chum, coho and chinook in that order. These species contribute 44, 29, 19, 7 and less than 1 percent respectively to the commercial fishing catch.

Cook Inlet is characterized on even years by good returns of pink, coho and salmon, however, on odd years the sockeye is the predominant species in the catch. Sockeyes have historically been the most valued species in the gillnet districts. Sockeye catches have suffered a general decline since the mid sixties.

Probable presence of significant numbers of adult salmon in the Inlet begins with chinook about 15 May and ends with coho about 20 September, a period of nearly 130 days.

Cook Inlet salmon are an important recreational resources. Most sport fishing for salmon to date has been in freshwater streams. During the period 1966-69 over 2,000 chinook salmon were caught by sport fishermen from four streams in Upper Cook Inlet, the Deshka River, Alexander Lake, and Chunilna Creek. During this same period the Anchor, Ninilchik, Kenai Rivers, and Deep Creek on the Kenai Peninsula yielded an estimated 1,900 chinooks. Escapement of chinook salmon to these four Kenai Peninsula streams totaled about 9,000 during these years. The Cook Inlet commercial catch for this period from the northern and central Alaska Department of Fish and Game commercial fish management districts totaled over 33,000 chinook salmon.

Steelhead, sea running rainbow trout, are found in Cook Inlet streams. They are much prized by sport fishermen.

Dolly Varden are widely distributed about the Inlet. They are suspected to move out to Sea under the ice, as they have never been observed in their outmigration. They move down to Kachemak Bay where they are often caught during the summer. They move back up the streams in July through October. Dolly Varden are an important sport fish in many streams around the Inlet, and are of minor importance to commercial fishermen.

Eulachon spawn in streams of Upper Cook Inlet beginning about 15 May to 20 May. They peak about the end of May. The run in the Kenai River is about a week earlier. Runs are known to occur in the Kenai, Twenty Miles, and Knik Rivers. In the Susitna, smelt proceed as far upstream as the Deshka River. The Placer and Portage Rivers supported runs prior to the 1964 earthquake, but have not recovered since.

A herring fishery has developed as the result of a demand for cured sac roe for the Japenese market. The two areas presently being fished are located in the vicinity of Seward and Halibut Cove. Both areas have had approximately ten seiners employed in the fishery. This is developing into a productive "off season" fishery as it usually commences in mid-May and ends in mid-June, after the king crab season and before the salmon season. The greatest demand as stated above is for sac roe; however, a small percent of the catch is being sold for animal (pet and zoo) food and sport and commerical fishing bait.

Shellfish

The king crab fishery began in Cook Inlet in Kachemak Bay on a commercial basis in 1951. The total Cook Inlet crab catch since 1960 has ranged from a high in 1963 of 8.4 million pounds to a low in 1965 of 2.8 million pounds. The average catch since 1960 is about 5 million pounds.

Value of the crab catch to the fishermen exceeded $1 million in 1971 and the first wholesale value of the catch exceeded $3 million. The fishery is estimated to have the potential for producing 5 million or more pounds per year.... Heaviest catches were made in the deeper waters between Augustine and the Barren Islands.

The Dungeness Crab fishery is sporadic and depends to a large degree on the strength of the Washington, Oregon and California fisheries. When these states experience a poor year the demand for Alaskan dungeness crab increase. In the near future it appears that outside markets will continue to influence the scope of this fishery.

The major portion of Dungeness catches are from Kachemak Bay, during the period June through October.

The commercial harvest of tanner crab in Cook Inlet began in 1968 and reached over 8.6 million pounds. This resulted partly from an increase in number of boats fishing for the species from 25 in 1970 to 81 in 1973.

When the fishery started, tanner crab catches were concentrated almost exclusively in the Kachemak Bay area. Since then tanner crab catch and effort has increased and expanded into other Cook Inlet areas.

Value of the catch to the fishermen was approximately $128,00 in 1972 and the first wholesale value was approximately $1,888,000. The fishery appears to be increasing rapidly throughout the State.

The shrimp harvest in Cook Inlet is made up of several species. Their greatest catches during abundance surveys by the National Marine Fishery Service were pink, humpy, and coonstripe shrimp. Spot and sidestripe shrimp were also abundant at some locations. Several species of the families Hippolytidae and Cragonidae were found to be abundant in most of Kachemak Bay.

Commercial harvest began in 1958 and has grown rapidly in recent years. There is presently a 5 million pound quota in effect for Cook Inlet. The first wholesale value of the shrimp pack for 1972 was $1.2 million.

Razor clams occur on the eastern beaches of Cook Inlet between the Kasilof River and Homer Spit with greatest abundance in the Clam Gulch and Deep Creek-Stariski Creek areas.

Use of this resource for sport has been increasing steadily in recent years until, in 1972, more than 400,000 clams were harvested by sport diggers. The majority of this harvest was made on the easily accessible eastern beaches, with more than 50 percent at Clam Gulch, although diggers are making increasing use of beaches on the western side. Half of the total sport effort is normally exerted during the month of May.

Scallops occur in Cook Inlet, but all areas are presently closed to commercial fishing. The only commercial effort was in 1969, when 240 pounds were harvested in the Kamishak area. Scallops were, however, taken in exploratory surveys conducted by the National Marine Fishery Service. Greatest abundance was in the Kamishak area between Augustine and the Barren Islands.

Marine Mammals

The principal marine mammals in Cook Inlet are beluga, sea lion, harbor seal and south of Augustine Island sea otters. Refer to the description of the marine environment in 8.2.1 for greater detail.

Threatened Species

The Susitna River Valley appears to be a major migration pathway for peregrine falcons. They can often be found on the Susitna Flats during the fall.

Ecological Considerations

This route passes through the following ecosystem types presented on Table 8.2.2-7. These systems have been discussed in 8.2.1.

The characteristics of the major ecosystems have been discussed in Section 8.2.1, Description of the Environment.

Economic Factors

Historical

See Section 8.2.1, Description of the Environment, for description of Interior Alaska Economic Factors. The construction of the Alaska Railroad brought large numbers of construction workers into the Cook Inlet region. Anchorage was founded as a railroad construction camp. By the time the railroad was completed in 1920 many more settlers had arrived from Europe and the United States.

Some few settlements such as Girdwood, Hope, Fairbanks and Wasilla originated as a result of early gold mining activities.

A very slow population growth occurred in South Central Alaska until World War II. The only major influx of settlers consisted of the Matanuska colonists who volunteered in response to a New Deal resettlement scheme. The Matanuska Valley colonists arrived in 1935 to create an American farming community in the meadows of the Matanuska Valley. While the experiment had many early problems, eventually several thriving dairy farms were founded. The community of Palmer rapidly emerged as the center of the colony.

Table 8.2.2-7 Ecosystem types

Type	Approx. % of Route
Alpine Tundra	7
High Bush	4
Lowland spruce-hardwood	39
Bottomland spruce-hardwood	15
Upland spruce-hardwood	35
	100%

Beginning with the establishment of military bases in Anchorage in 1940, the first significant wave of migration since the building of the railways came to central Alaska. Anchorage, whose population had increased little since the end of railroad construction, grew in the next decade from 3,000 to 40,000 people. The population of the smaller communities did not increase at the same rate, and in fact, many lost population as their citizens moved to Anchorage in search of jobs.

The next population influx began with the building of the DEW Line radar installations from 1949 to 1958. While the actual sites were constructed all over Alaska, Anchorage served as the administative, financial, and logistics center for the greater part of the effort. The population continued to increase rapidly during the decade of the 1950's while other communities remained relatively stable.

Oil was found on the Kenai Peninsula in 1957. The city of Kenai and its environs immediately began a period of rapid growth which culminated in 1964. The next phase of oil development in Cook Inlet was the building of offshore platforms from 1966 to 1968. This brought a new type of resident to Alaska--one whose main experience had been in oil exploration and development. Anchorage probably acquired more permanent population from the oil than Kenai, however, since most of the major oil company offices located there.

The Alaska earthquake of 1964 brought a new round of construction activity to Southcentral Alaska which generated further immigration and developed economic stability. And the discovery of oil at Prudhoe Bay in 1968 gave the population increase still another new impetus.

Principal Economic Activities, Employment and Income

Major sectors of the Southcentral Alaska area economic base are commercial fisheries, petroleum, timber, tourism, and government-military and civilian.

The Cook Inlet region possesses Alaska's most diversified economy. As noted previously, Anchorage is the State's largest community as well as the Southcentral area's economic center. Government, trade, and services comprise the major portion of the area's total employment. Construction and transportation are also important. Making relatively less significant contributions are the financing, mining, and manufacturing industries.

In the government groups, employment is divided more or less equally between state, local, and federal sectors. The major federal employer is the Department of Defense. Most of its employees are concentrated in Anchorage's two major military installations, Elmendorf Air Force Base and Fort Richardson. State and local government employment in addition to employees of the State of Alaska, includes those of the Greater Anchorage Area Borough, the Kenai Peninsula Borough, the Matanuska-Susitna Borough, and the cities within these boroughs.

After government, the two groups having the largest employment are trade and services. Their importance as sources of employment for Cook Inlet area residents is a further manifestation of the area's relatively concentrated population and high degree of economic diversity, as well as a level of demand for goods and services which is substantially above most other parts of Alaska. The importance of construction is largely due to high levels of expansion experienced by the Anchorage area since 1968. This growth period can partly be attributed to anticipation of the trans-Alaska pipeline project which encouraged much new construction in both the public and private sectors.

High levels of employment in the transportation industry reflect Anchorage's position as a major transportation center, not only for the Southcentral area but for the State as well. The Port of Anchorage handles most of the waterborne freight moving into southcentral and northern Alaska. Anchorage International Airport serves as a hub for commercial air traffic throughout Alaska, and is an important stopover for trans-polar flights of several major international air carriers. Anchorage also serves as the transfer point for goods brought into the area by air and water, then distributed by truck or the Alaska Railroad to more remote areas.

Although they exert relatively little direct impact on total employment, mining, finance, insurance, and real estate play an important role in terms of the secondary employment they generate. Most people employed in mining are engaged in activities relating to petroleum extraction from fields in Cook Inlet and the Kenai Peninsula. A substantial portion of the royalties and taxes collected by the State as a result of this production is returned to the area in the form of jobs in state government and through revenue sharing with various local governments. Similarly, the financial sector, in spite of its small employment exerts considerable economic leverage as the banking center of Alaska.

The Native employment situation has been a countervailing trend to the increasing per capita income, as in other areas of Alaska. Eskimos and Indians comprise most of the poor in Fairbanks. Native unemployment in the Interior region is almost five times that of the total work force.

A similar situation exists in the Cook Inlet Subregion. For the most part only a small percent of the Natives have been able to obtain the economic standard of living that the non-Natives have achieved.

Natives in the Susitna area still face high unemployment rates and near poverty conditions. The higher paying jobs in the area are typically held by non-Natives. Seasonal and temporary jobs, often low paying are held by the Natives.

General observations and statistical data confirm that Natives are able to obtain employment in times of accelerated economic activity but that the choice of jobs is limited largely to the unskilled lower paying categories, and that during off seasons, leveling off periods in the economy, or in times of recession, the Native has not been able to remain in the labor market.

Natives need to be trained and experienced to the point where they can compete successfully in the labor market for the better paying, more highly skilled and technical opportunities and to the point where they can attain flexibility and high degree of job mobility. Until this happens, they will continue to bear the brunt of underemployment/unemployment.

In his article "No Alaska Recession," Richard Solie of the University of Alaska (Alaska Const. & Oil, Jan., 1975) commented on near term future and long term growth prospects:

Native Subsistence--The communities of Wiseman, Evansville/Bettles, Stevens Village, Minto, and Eklutna are the native villages that would be encountered along this route. The inhabitants of these villages depend, for the most part, on the natural resources of the area for their subsistence. Those villages that are served by ground transportation are trending toward a cash based economy but this is not the dominant means of subsistence at this time.

"At least until completion of the (oil) pipeline, the Alaskan economy can be expected to remain in a perpetual boom. Other factors which will augment this growth in employment are further increases in State employment and expenditures (such as $189 million in bond issues approved by the voters in November), development activities by the Native Regional Corporations continued growth in the support sector of the economy, oil exploration and development activities on the North Slope and elsewhere in Alaska, and the possible construction of a trans-Alaska natural gas pipeline. The long term growth prospects of the Alaskan economy are extremely bright. Petroleum will continue to be a dominant element in all sections of the economy."

Native corporations have signed agreements with oil campanies to undertake geological explorations for the use in selecting lands under ANCSA.

Even more important to Alaska than a continued construction boom is the availability of additional natural gas for use in the state and particularly in the Interior. A gas supply in the Interior would create the potential for development of a petrochemical industry, and it would also provide a low cost fuel for other industrial development.

Significant potential exists for development in the lumber industry, the mineral industry, tourism, agriculture and fishing.

For many years the support sector (including such industries as transportation, communications, public utilities, trade, finance, and services) has been the most rapidly growing segment of the Alaskan economy. Estimates are that this sector will continue to be the most rapidly growing in the years immediately ahead.

As the size of the Alaskan market grows, and with abundant supplies of energy, it will become increasingly economical to establish manufacturing plants in Alaska. The manufacturing sector can thus be expected to show significant growth in the years to come.

Recently, Alaska's potential for agricultural development has caused a great deal of interest, and studies have indicated that the state has approximately 13.6 million acres of potential crop lands and large areas of range land of which only a very small portion is presently being used.

Overall, it appears that both the short and long-term prospects for the Alaskan economy are excellent.

Sociological Factors

See Section 8.2.1, Description of the Environment, for a discussion of Interior Alaska's sociological factors.

The present forms of municipal government--cities, boroughs, and service are derived from the State Constitution and statutes enacted since Statehood in 1959. The Borough Act of 1961 authorized incorporation of boroughs.

Municipal law can be found in Title 29 of the Alaska Statutes. In addition to granting legal authority for the conduct of municipal affairs, the Title establishes the structures and processes for cities, boroughs, service areas, and unified municipalities to deliver services and assume additional powers. The Title also describes the processes to consolidate and merge communities, incorporate new cities and boroughs, and dissolve existing municipalities.

Current statutes describe two general classes of municipality, the city and the borough.... most (cities) are general law cities of the first or second class, whose authority is defined in state laws uniformly applicable to all cities in one or the other of the general law class. Some cities operate under charters adopted after referendum among residents.

Boroughs are units of government embracing larger areas; either an urban community and surrounding metropclitan areas, or several smaller communities and the surrounding undeveloped area.

Statutes regulate the division of authority between incorporated cities and boroughs and describe how powers may transfer or be assumed by the borough. Once the borough assumes a power it may no longer be execised by a city within the borough.

There are four organized boroughs within the areas of the pipeline segments considered and almost all the localities and cities and municipalities are within these borough boundaries. The boroughs are: Fairbanks-North Star; Matanuska-Susitna; Greater Anchorage Area; and Kenai Peninsula.

Reflecting its relatively urban nature, the Cook Inlet area including Anchorage, contains the largest share of the Southcentral Region's total population.

Whites make up the largest share of the areas' total population, however, the composition of the non-white population tends to vary depending upon the area. In the adjoining areas, most non-whites are Alaska natives. But in the Cook Inlet area, the populaticn contains a significant proportion of blacks, filipinos, and Orientals, as reported by the 1970 census.

Land Use

Existing and Potential Land Use

Agriculture and Forestry--This route, beginning in Fairbanks and heading southward, would travel through potential agricultural lands for a distance of approximately 75 miles south of Fairbanks. The route would then proceed through the Alaska Range where there are no potential agriculture lands. Emerging from the southside of the Alaska Range, the route would enter the upper Susitna Valley, where it again enters potential agriculture lands.

North of Anchorage lies the Matanuska Valley which is Alaska's most intensively developed agricultural area. Major settlement period occurred during the depression years of the 1930's when the government sponsored a "colonization" program involving moving several hundreds of families from drought ridden states.

Today, the area still has primarily family farms producing grain, hay, and quality vegetable crops. Dairy operations supply some of the needs of the Anchorage area.

Portions of the route on the Kenai Peninsula have agriculture potential, but for the most part lie within Federal reserves. Refer to figure 8.2.2.-14 for relationship of the route to potential agricultural and commercial forest lands.

The forestry resource occurs on roughly the same lands that are the potential agriculture lands. The heavier stands of commercial forest occur surrounding the Cook Inlet area. The prime species in the upper Susitna and Cook Inlet areas is white spruce. There are limited stands of cottonwood and considerable volumes of paper birch in the upper Susitna Valley.

The Alaska Division of Lands regularly conducts timber sales for harvest of the renewable forest resources in areas adjacent to the route. Principal sale areas are between Fairbanks and Nenana, in the Susitna Valley, and on the Kenai Peninsula.

The Forest Service timber harvest program is primarily in areas away from the route. The U.S. Fish and Wildlife Service occasionally sells timber from the Moose Range for habitat conversion purposes.

Industrial Lands and Transportation--This route borders the most highly developed industrial lands in the State of Alaska. The entire route from Fairbanks to the Anchorage area is an existing transportation corridor that has three existing tranportation facilities within it. They are the Alaska railroad, the Fairbanks to Anchorage highway, and overhead, electrical transmission lines. Just prior to entering the Alaska Range, the route would pass near Alaska's only operating coal mine, owned by the Usibelli Company. This strip mine provides the fuel for an electric generating plant in Fairbanks.

In the upper Susitna Valley area, the route passes close to a proposed hydroelectric power project. This project is known as the Susitna River or Devil's Canyon Project and could include a total of four dams.

A primary industry of the Cook Inlet area is oil and gas production. The petroleum products industry, since 1959, has produced 1-1/4 billion dollars worth of oil and gas. It is estimated there may be as much as 7.9 billion barrels of oil and 14.6 trillion cu. ft. of gas reserve in the Cook Inlet basin.

The Cook Inlet and Gulf of Alaska ports available to this route are the terminal areas for the shipping and transportation industry in Southcentral Alaska.

Anchorage is also a center for international air transportation. Due to availability of transportation, the entire region traversed by the route is a primary center for the state's third largest industry -- tourism and recreation.

Residential--The Greater Anchorage area and the towns of Eagle River and Chugiak contain approximately one half of the residential area for the entire State. These residential areas lie along the foothill slopes of the Chugach Mountains on the east to the shores of Cook Inlet.

The residential areas contain largely single family housing. There are, however, a few areas of high-rise apartments, town house and condominimum development and more are being built. Throughout the residential areas there are areas of open space. The pipeline right-of-way would be in close proximity to residential areas for about 40 miles around Anchorage-Eagle River.

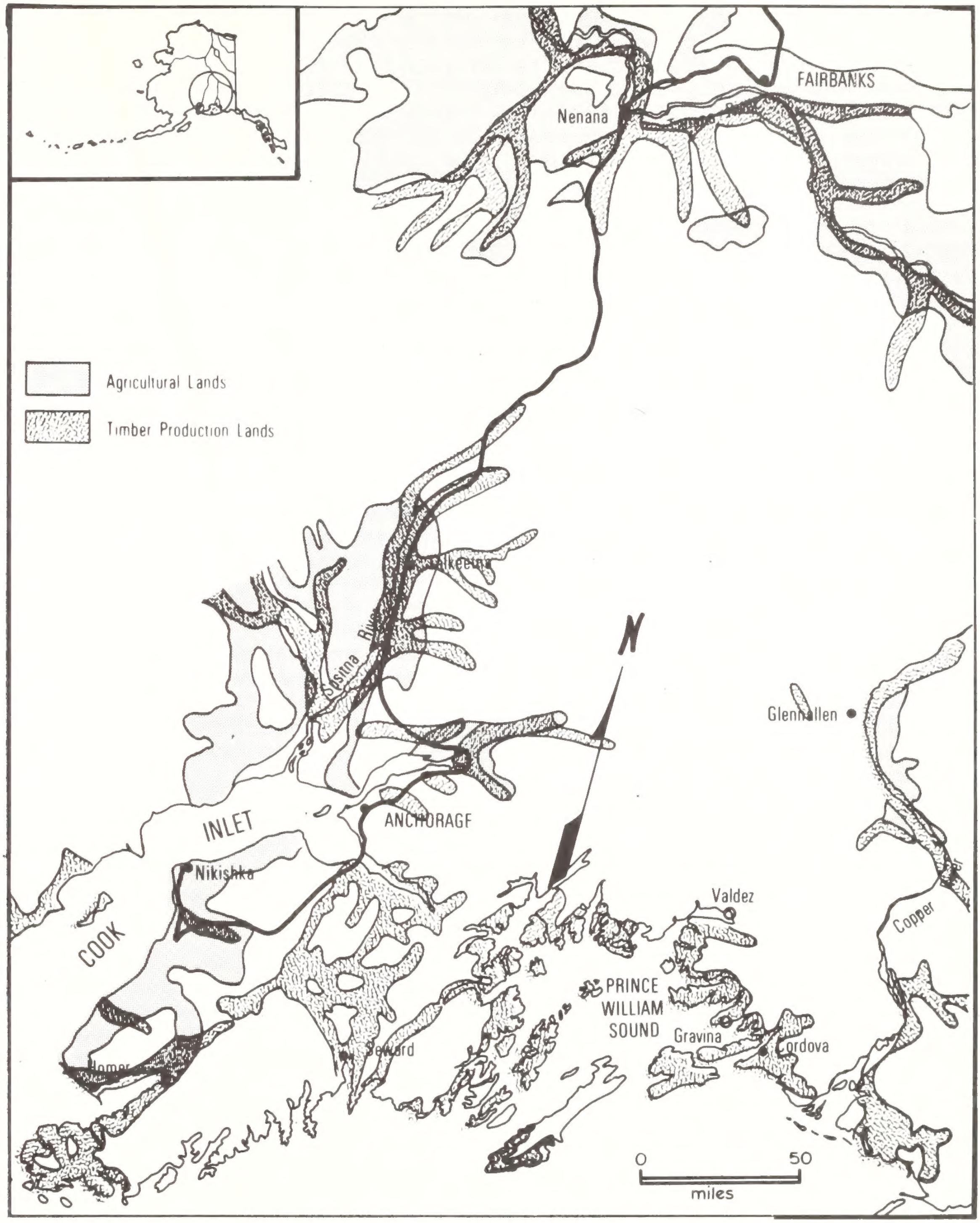


Figure 8.2.2-14 Potential agricultural and timber lands

Mineral Extraction and Processing--North of the Alaska Range the primary mineral extraction area is the existing Usibelli coal mine near Healy. In addition to this, there is on-going production of gold, lead, silver, zinc and antimony in areas around Mt. McKinley National Park. South of the Alaska Range the oil and gas produced in fields in the Cook Inlet basin have far exceeded other minerals in value. Coal is present in Susitna, Matanuska, and Kenai Fields. The total coal resource is estimated to be approximately 2 1/2 billion short tons.

Geothermal--Geothermal potential is considered to be high south of the Alaska Range. Clay deposits which could be used for commercial brick manufacturing occur at several locations within the Susitna-upper Cook Inlet Area. Gypsum and limestone deposits occur in several locations within 50 miles of this route. Metallic materials are present in several districts. The only large scale operation in the past has been a gold operation in the Willow Creek area. In the southern Alaska Range metallic sulphide minerals are common. Minor amounts of gold have been taken from placer gold locations throughout the area. Several types of iron ores, copper ores, and chrome deposits also exist in the Cook Inlet sub-region.

The Susitna River and the other large rivers in the sub-region are the locations of gravel deposits. No estimate of the gravel volumes is available. Sand and gravel supplies in the Anchorage area are in high demand and short supply.

Transmission Facilities and Utilities--An integrated electrical power system operates within the area through which the pipeline would pass. Natural gas exists in commercial quantities in the area and is the major fuel for the production of electricity by Chugach Electric Association (CEA), which serves 25,000 members plus the City of Anchorage with 14,000 customers.

There are two hydroelectric projects in operation. The Alaska Power Administration operates the Eklutna project north of Anchorage, which has a generation capacity of 30,000kw. The Cooper Lake dam and generator located on the Kenai Peninsula has a generation capacity of 15,000 kw, and is owned by the CEA.

CEA makes use of the following generation capabilities: the Knik Arm steam power plant with 5 natural gas-fired boiler units that has a base load capacity of 14,500 kw and is located in Anchorage; the Cooper Lake hydroelectric project that has two generating units of 15,000 kw capacity; the Bernice Lake power plant located on the Kenai Peninsula with two natural gas-fired units having 27,800 kw capacity; the Beluga Station on the west side of Cook Inlet near Tyonek with three natural gas-fired units having a capacity of 83,800 kw; and the International Station near Anchorage International Airport, that has three natural gas-fired units having a capacity of 46,500 kw. In addition, CEA can purchase 9,000 kw of power from the Eklutna project.

Modern long distance communications facilities available in the subregion are highly developed compared with other areas of Alaska, although some elements of the system are considered out of date. Present facilities include the military's "White Alice" microwave and tropospheric scatter system, commercial (RCA Alaska Communications) terrestrial point to point and satellite wide band microwave stations, MF, VHF, and UHF single or multi-channel radio telephone terminals, open wire (communications lines strung above ground between poles), and a toll switching center in Anchorage.

Prior to 1971, commercial long distance service to, from, and within Alaska was provided by the federal government through the Alaska Communications System (ACS) administered by the Air Force. In 1971 this system was transferred to RCA Alaska Communications, a subsidiary of RCA Global Communications, through the purchase of ACS.

The present communications network within or through the subregion includes the large Bartlett Earth Station near Talkeetna, purchased from COMSAT by RCA Alaskcom; a microwave link between Anchorage and the Bartlett Earth Station; a recently constructed microwave system between Talkeetna and Fairbanks; open wire along the Glenn Highway between Anchorage and Glennallen and along sections of the Alaska Railroad between Anchorage and Fairbanks and Portage-Whittier-Seward (the Alaska Railroad uses microwave for communications between Anchorage and Portage); and the "White Alice" tropospheric scatter system from Kodiak Island and the Alaska Peninsula to the Kenai Peninsula, from Soldotna to Glennallen, and from Neklasson Lake near Palmer to Hinchinbrook Island in the Gulf of Alaska.

Sewer and water utilities are relatively well developed in some of the urban areas of the subregion. The City of Anchorage provided treated water both within and outside city boundaries and Central Alaska Utilities serves users in the Anchorage Borough outside of the City's service area. There are a number of small private water utilities serving subdivisions. The Greater Anchorage Area Borough is responsible for sewage collection and treatment. A primary sewage treatment plant is located on Point Woronzof. The central area of Eagle River is served by a sewage lagoon.

Palmer is the only community in the Matanuska-Susitna Borough with community water and sewer utilities. Community water and sewer utilities are available in Homer, Kenai and Soldotna. Tyonek has a community water utility.

Wells and septic tanks or cesspools are used in the more rural areas of the subregion and the need for more modern facilities is becoming acute in Wasilla, the Fishhook Road area, Talkeetna and Big Lake.

Land Status and Ownership

The route described in 8.2.2 basically follows the Alaska Railroad to a point near Anchorage. A fine point of status depends on whether the route is located within the dedicated railroad right-of-way. (see figure 8.2.2.-15)

General land ownership along the route independent of the railroad right-of-way is largely the State of Alaska. Approximately 35% of the 425 mile route is patented to the State or tentatively approved for patent. An additional 40% has been selected by the state. Third party interests, i.e., sales by the state, have not been analyzed. Through the Susitna valley to the Knik River almost all the route is privately owned.

From the point at which the route leaves the railroad, circling around Anchorage to Potter, extremely mixed ownership would be encountered. It may be assumed that a major portion of this segment could traverse the Fort Richardson Military Reservation. If Chugach States Park is crossed, there would still be some 10 miles from the Park to Potter which is mixed private ownership.

After crossing Turnagain Arm of Cook Inlet, there is an estimated 10 miles of the route in the Chugach National Forest and 60 miles within the

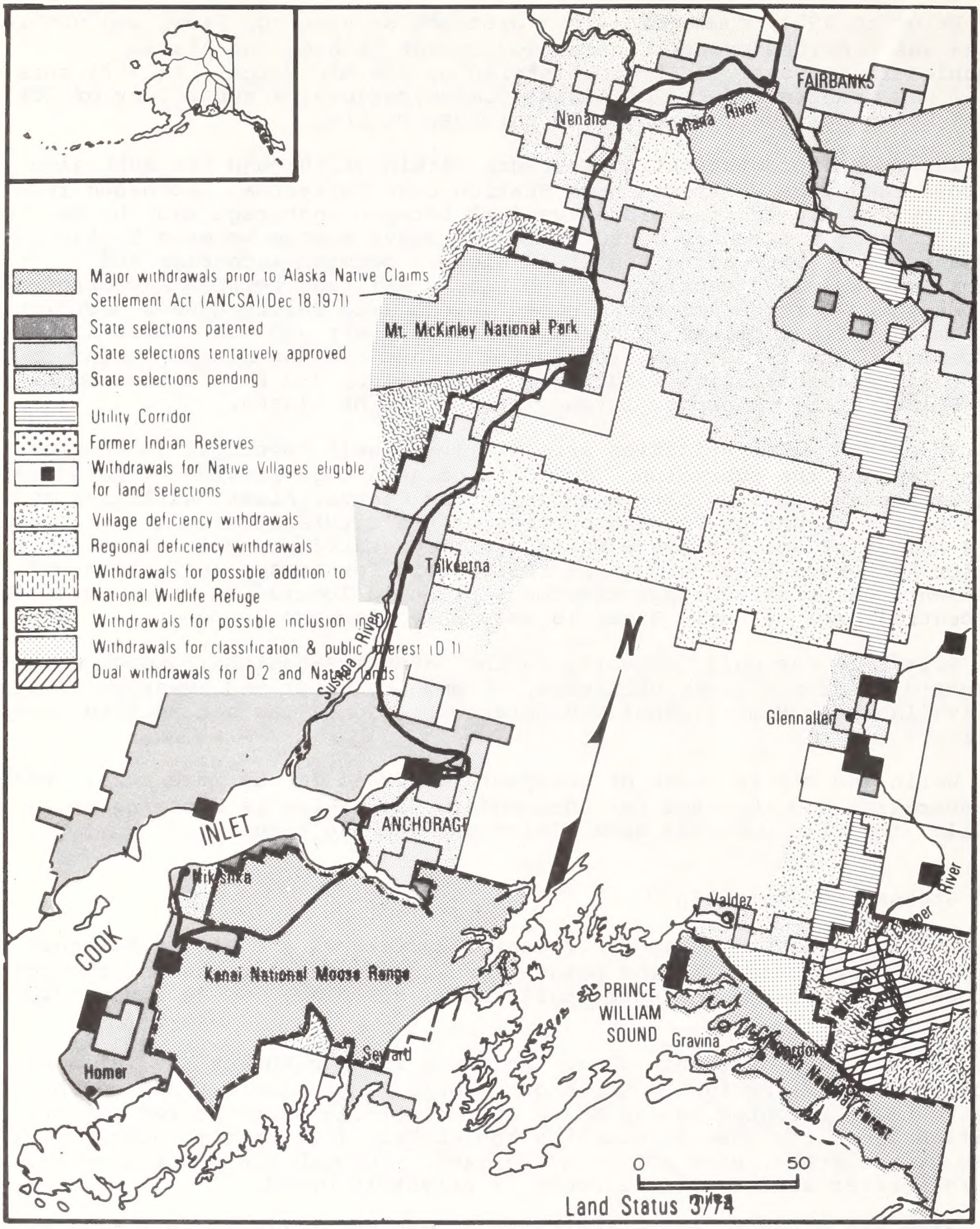

Major withdrawals prior to Alaska Native Claims Settlement Act (ANCSA)(Dec 18 1971)
State selections patented
State selections tentatively approved
State selections pending
Utility Corridor
Former Indian Reserves
Withdrawals for Native Villages eligible for land selections
Village deficiency withdrawals
Regional deficiency withdrawals
Withdrawals for possible addition to National Wildlife Refuge
Withdrawals for possible inclusion in
Withdrawals for classification & public interest (D 1)
Dual withdrawals for D 2 and Native lands
FAIRBANKS
Nenana
Tanana River
Mt. McKinley National Park
Talkeetna
Susitna River
N
Glennallen
ANCHORAGE
INLET
COOK
Nikishka
Kenai National Moose Range
Homer
Seward
Valdez
PRINCE WILLIAM SOUND
Gravina
Cordova
Copper River
Chugach National Forest
0
50
miles
Land Status 3/74

Figure 8.2.2-15 Land status

Kenai National Moose Range. Upon leaving the moose range, the last several miles to the Nikiski site is mixed state and private ownership.

Lands available for selection by Native Corporation will be encountered near Nenana, Cantwell, Eklutuna, and possibly near Kenai. The latter is subject to determination of status of Cook Inlet Regional Corporation deficiency lands which is now a matter of litigation.

In the Brooks Range this route would be about 10 miles east of the proposed gates of the Arctic National Park. The route would also go within 10 miles of the proposed Yukon Flats National Wildlife Refuge and would also parallel the eastern boundary of a proposed addition to Mount McKinley National Park.

Archeological, Historical and Unique Areas

This alternative route passes a very important archeological site and the possibility is high for further significant finds in the area. The Dry Creek Archeological Site, entered on the National Register in September of 1974, is thus far the oldest reliably dated site of human occupation in Alaska. Artifacts from the site show certain similarities to the late Upper Pleistocene Diuktai culture of northeastern Siberia. The site is also capable of yielding important paleoecological information. It is located in the Lignite vicinity, about 100 miles south of Fairbanks.

Historic sites along this section of the route which have been entered on the National Register of Historic Place are the George C. Thomas Memorial Library and The Nenana Steamer (Fairbanks), the Knik Site (Wasilla), the Independence Mines (Palmer), and the Old St. Nicholas Russian Orthodox Church (Eklutna).

The route follows the Alaska Railroad line, which runs from Seward to Fairbanks. The Railroad line was completed in 1923. Roadhouses were built simultaneously with the construction of the railroad. At one time 27 roadhouses existed along the route. Of these, only the Wasilla roadhouse (Knik Site) is entered on the National Register, however, others may be entered at a later date.

Only general archeological surveys have been conducted along the east side of Cook Inlet. Prehistoric occupation did occur in this area, and further archeological investigations are expected to yield positive results.

Insufficient data exists to estimate the paleontological potential along the route.

Virtually no archeological work has been conducted on the north and west sides of Cook Inlet. These areas were occupied in prehistoric times and investigation is expected to yield archeological finds.

The following unique areas have been identified by the Joint Federal State Land Use Planning Commission in their 1973 Proposal for an Ecological Reserve System for Alaska.

The Ester and Fox Tailing sites and the Ester Dome area, all of undetermined size, date from dredge operation in the Fairbanks area in the 1930's or possibly 1920's. They provide an unusual opportunity to study progressive weathering, soil formation, and plant succession on surfaces of known age.

The Nenana Canyon site of undetermined size, is located along the Alaska Railroad and has stratigraphic exposures of Pleistocene lake clays and delta deposits. Landslides, slumps, and earthflows occur widely and have had a severe effect on the railroad.

The Cottonwood site in the Susitna Basin of about 5-10,000 acres contains a hybrid of Populus trichocarpa and P. Balsamifera. It also has other vegetative types representative of the Susitna Basin.

The Susitna River-Montana Creek area of about 40,000 acres contains an important upland hardwood forest of the Susitna Basin. The area has been proposed by the Alaska Division of Lands as an experimental forest.

Recreational and Esthetic Resources

Existing Facilities

See Section 8.2.1 for description of the recreational and esthetic resources of Interior Alaska.

Recreational use of this region of Alaska is high and there are many high quality recreation areas available. The State's population is concentrated along the route and access to the area is more highly developed than to any other area of Alaska.

The two million acre Mount McKinley National Park lies roughly midway between Anchorage and Fairbanks adjacent to this route. It is a scenically splendid area with the awesome form of Mt. McKinley, surrounding mountains, and rolling alpine tundra and abundant wildlife resources.

In 1974 (January through September) approximately 162,000 recreational visits were recorded in Mount McKinley National Park, accounting for a total of 104,037 overnight stays. Visitors engage in wildlife viewing, camping, hiking, mountain climbing. Facilities in the Park include a concessioner operated lodge with accommodations for 488 persons a night, campgrounds for campers, trailers, and tent campers along the Park road with a total of 208 camping units. Data on recreational overnight stays at Mount McKinley National Park for January through September is as follows:

Concessioner Lodging	28,026
Park Campgrounds	56,635
Park Backcountry	17,105
Youth Hostel and Group Camp	2,271

A shuttle bus is available to take visitors along the Park road to Eielson Visitor Center and Wonder Lake. The concessioner operates an early morning wildlife tour.

The State of Alaska has developed high quality recreation areas along this route. Visitor statistics for specific areas are unavailable. The following is a list of recreational areas administered by the Division of Parks, State of Alaska. Recreational uses, size, and location are given.

Big Lake (South Wayside)--Wasilla, 16 acres camping, picnicking, canoeing, boating and fishing

Big Lake (East Wayside)--Wasilla, 19 acres camping, picnicking, swimming, canoeing, boating and fishing

Rocky Lake Wayside--Wasilla, 48 acres camping, picnicking, canoeing, and boating

Nancy Lake Recreation Area--Willow, 22,685 acres camping, picnicking, canoeing, and fishing

Nancy Lake Wayside--Willow, 35 acres camping and fishing

Willow Creek Wayside--Willow, 40 acres camping and fishing

Denali State Park--Cantwell, 282,000 acres camping,canoeing, fishing and swimming

Chugach State Park--South Central, 495,204 acres camping, picnicking, fishing, canoeing and hiking

Mirror Lake Wayside--Eagle River, 90 acres picnicking, boating, fishing, canoeing, and swimming

Peters Creek Wayside--Eagle River, 52 acres camping, fishing and picnicking

Bernice Lake Wayside--Kenai, 7 acres camping, boating, canoeing, fishing and swimming

Captain Cook Recreation Area--Kenai, 3,620 acres camping, boating, canoeing, fishing and swimming

Proposed Areas

Mount McKinley National Park was established in 1917. A proposal exists to add approximately 3.18 million acres to the present park which now includes about 2 million acres. About half of the additions are to the north of the existing park, and constitute critical wolf, sheep, moose and caribou range necessary to ensure the continued viability of the ecosystem of the Mount McKinley area. The area also has important waterfowl values. The remaining half of the added acreage is to the south of the park. It includes part of the Mount McKinley mountain massif not now within the park, spectacular glacial systems, and the intricately dissected, awesomely beautiful Cathedral Spires. Lowland areas in the southern portion will provide ecologic diversity for the park and opportunity for recreational use and access. These additional areas would be managed as natural areas with the primary objectives of preserving the large mammal ecosystem and the scenic beauty of the area; development would be minimal, with emphasis on the recreation potential of the area in its natural condition. Headquarters would be relocated from its present site north of the Alaska Range to the south side of the range.

A cooperative planning and management zone, adjacent to the south and east boundaries of the expanded park, has been designated on the maps referred to in the legislation. This area encompasses the threshold lands to Mount McKinley. Within 3 years from the date of enactment of the title, the Secretary would be required to submit a report to Congress on whether land-use controls needed for proper protection of the park have been instituted by the State and local governments with respect to this zone. Comments of the Governor and the Joint Federal-State Land Use Planning Commission will be solicited and submitted to Congress as well.

It is anticipated that the proposed additions, combined with developments in nearby Denali State Park and in the Cooperative Planning and

Management Zone will serve to meet a significant portion of the growing demand for recreational opportunities on the part of residents of southcentral Alaska.

Air Quality and Environmental Noise

Natural air quality along this alternative route has been degraded by the use of the transportation systems, by city and industrial development, and by farming.

South of the Alaska Range natural air quality at times is seriously degraded by a large amount of air-borne dust. This is most prevalent in late spring, fall, and winter. The large glacier till area in Cook Inlet and along the major rivers of the area are the source of this dust. See Section 8.2.1, Description of the Environment, for a discussion of air quality factors in Interior Alaska.

Because of the large amount of development, the transportation routes, and the large mobile population, there is no place along the route that does not experience much man-caused noise.

Impact Analysis

Summary of Major Impacts

1) Climatic conditions such as extreme cold, blowing snow, and ice fog could cause delays in construction and maintenance schedules and in repair activities during operation of the pipeline.

2) Permafrost, frost heave and slope stability, expecially on ice rich soils would affect the construction and integrity of the pipeline. These would have a particular impact if the construction schedule is extended.

3) The seismicity is very high in the southern section of the route with a potential of earthquakes of magnitude 8.5.

4) The potential of frost bulb forming around the pipeline at stream crossings is significant in relation to the number of streams crossed. Frost bulb formations could change the flow regime and cause channel changes that would have an adverse impact on manmade facilities nearby the pipeline.

5) The addition of toxins and pollutants and the withdrawal of water related to construction and maintenance operations would have a major impact on the ecology of areas adjacent to the pipeline.

6) The high suceptibility to fire and resistance to control of the lowland spruce + hardwood vegetation of the Kenai Peninsula gives this area a high potential for damage to property and human life.

7) The socio-economic impact on Fairbanks and Anchorage would be both beneficial and adverse. The beneficial impacts include - an increase in trade to local businesses; an increased tax base for cities; and an increase in cultural activities. The adverse impacts include - an increase in crime; crowding of schools; inflation; a lower standard and shortage of housing; and an acceleration in the decline of Native culture.

8) The major impact to land use would be favorable as the route follows existing transportation corridors the whole way.

9) The archeological sites of Nenana Canyon, Ester and Fox Tailings, and Ester Dome could be destroyed or damaged. The impact on undiscovered sites would be adverse or favorable in that they could be destroyed or discovered.

10) The pipeline route would have a major impact on Mt. McKinley National Park where the route passes close to and crosses inside its eastern border.

Shipping Route--Cook Inlet to California

The presence of ice in Cook Inlet could at times interfere with the LNG tanker traffic. These impacts and other impacts are analyzed in greater detail in the following discussion.

Detailed Analysis

Climate

The construction, operation, maintenance, or repair of this alternate system could have some effect on prevailing climatic conditions along the route. Available information indicates that there might be some microclimatic changes resulting from compressor stations and the LNG plant. These changes are covered in greater detail under Air Quality.

Climate, however, can and would affect the construction, operation, and maintenance of the line. Primary impacts would be that construction activities will be limited during the winter by extreme cold, blowing snow, icefog and ice conditions on Cook Inlet. Operation and maintenance would be adversely affected by climate during the winter by the same items mentioned for construction and by high winds in the summer, by fog and by adverse weather during the spring breakup period.

These factors could delay construction and maintenance schedules and would at times cause delay in repair activities.

Ice in Cook Inlet rarely occurs in large concentrations south of the Forelands due to warmer water temperatures. Only when the air temperatures are extremely low for prolonged periods does the ice extend south of the Forelands. Due to the tidal action in Cook Inlet the ice is not in a solid sheet but is in a shattered condition. At Nikiski the mean tidal range is 17.5 ft., the diurnal tidal range is 19.8 ft. and the extreme tidal range is 32 ft. The maximum currents at Nikiski are 3.8 knots at floodtide and 2.6 knots at ebb tide. The wave heights range from 4 - 12 ft.

Topography

This alternate system would be built close to primary transportation or transmission routes for its entire length.

The mound of dirt over the ditch and the associated compressor stations, airfield, borrow pits etc. would show as a visual impact upon the natural topography (landscape) of many areas.

In some areas such as the Arctic Slope, Broad Pass near Mount McKinley, and the undeveloped portions of the Susitna Valley, this visual impact would be greater than in others because of the present lack of development and/or because it would be highly visual to a number of people.

Geology

This alternate system will have little effect on the geology of the area through which it passes. Construction and operation would have an impact on mineral resources of the area because increased and improved access will encourage extraction of these minerals.

Many facets of the geology of the area, however, would react upon the pipeline system. Among these are permafrost, frost heave, slope stability and earthquakes.

Detailed discussions of the impacts of permafrost, frost heave and slope stability have been included in Section 8.2.1, Impact Analysis.

The earthquake potential along the route has been specified in terms of maximum expectable earthquakes as follows:

Segment	Magnitude (Richter Scale)
Fairbanks to Rex	7.5
Rex to Broad Pass	8.0
Broad Pass to Palmer	7.5
Palmer to Nikiski	8.5

This route is characterized by a high level of seismicity associated with the northwest extension of the Aleutian seismic belt into central Alaska. In addition to the great 1964 earthquake (magnitude 8.5), epicenters of several shallow shocks of magnitude 7.0 and larger have been located within 100 miles of the corridor in this century.

Earth movements and tsunamis could have serious effects upon the pipeline, LNG plant, and shipping with "worst case" effect of destroying facilities including the pipeline itself, the LNG Plant, and wrecking some of the shipping fleet.

Soils

Soils south of the Alaska Range (Figure 8.2.2.-9 and -10) are less affected by permafrost than those north of the Range. The climate is much less severe and impacts on soil, and secondarily on vegetation, would be much less severe than in the northern sections.

Spills of toxic materials used during construction and operation of the project would seep into the deeper soils of this area more readily than in permafrost soils and would kill or slow down growth over a long period and a large area.

Operation of the pipeline in a chilled buried mode would encourage the growth of a frost bulb of soil around the pipe which would change the thermal regime of the soils and secondarily, slow down the growth of the revegetation effort on the disturbed soils over the line.

Water Resources

Impacts of this alternate system on water resource north of the Alaska Range have been discussed in Section 8.2.1, Impact Analysis.

South of the Alaska Range the route would cross many major salmon spawning streams in the Susitna Basin south to Anchorage and on the Kenai

Peninsula. The presence of a chilled pipeline beneath the bed of these streams could affect the thermal regime of the water which would adversely affect fish spawning success and production of fish and invertebrates by delaying spawning past the optimum egg laying time, kill the eggs or slow down the development of the young.

Silt-laden waters from erosion of areas opened up by construction activities would degrade the surface water quality which would reduce stream biotic production with a resultant loss of fish and invertebrate populations and would lower aesthetic values.

The streams in this area receive a large amount of recreational use by the residents of Anchorage, the Matanuska Valley and the Kenai Peninsula. A lowering of water quality and fish production would also lower the recreational use of the streams and cause the fishermen, boaters, etc. to go elsewhere which in turn could reduce the quality of recreational enjoyment of other areas because of over-crowding.

Impacts on ponded water, groundwater, and Cook Inlet would be the same as those listed in Section 8.2.1, Impact Analysis.

The formation of soil and frost bulb around the pipe under the stream could change flow regimes and cause channel changes which would adversely affect highways, railways or other manmade facilities in close proximity to the route by eroding away the ground on which the facility is built.

Vegetation

This alternate system route crosses most of the vegetative types in Alaska. Descriptions of these types and project-caused impacts are more fully described in Section 8.2.1, Impact Analysis.

Impacts would include total destruction of vegetation by covering, and project-caused erosion and pollutant spills; species change because of reseeding programs or thermal regime changes in the soil over the pipeline; or change in natural plant succession on disturbed areas. Soil moisture changes might be brought about by the change in drainage patterns around, over and under the pipe which would change the vegetation over the pipe.

The major difference between the Cook Inlet Route and Gravina Point Route (8.2.1) is that the Coastal timber belt on the Kenai Peninsula is much more susceptible to fire than the coastal timber along Prince William Sound. Fire incidence on the Kenai Peninsula is high. Fires are quite resistant to control and there is a much greater potential for damage to property and human life than on Prince William Sound. Fire control and safety measures will need to be increased in this area.

Wildlife

Impacts of this alternate natural gas trasmission system on wildlife in the area from Prudhoe Bay to the crest of the Alaska Range has been described in Section 8.2.1, Impact Analysis.

South of the Alaska Range project-caused impacts on mammals and birds would be the same as described in Section 8.2.1, Impact Analysis, of this report.

Animal species are the same for this route as others. There are moose throughout the route. Sheep inhabit the Mount McKinley area and the

Talkeetna Mountains on either side of the route and some caribou from the Nelchina herd and the Kenai Peninsula herd may become involved in their summer range. Furbearers include, beaver, mink, weasel, lynx, wolverine, and fox. Large carnivores are represented by grizzly bear, black bear, and wolves. There are also marmots, pikas, hares, many species of voles, mice, and other microtines.

These animal species would be adversely affected through project-caused disturbance resulting in loss of habitat or by causing animals to avoid the project area. Increased access would increase pressure from hunting and human disturbance.

Ducks, swans, other waterfowl and shorebirds are represented in the area. There could be adverse impacts to the wildlife in the proposed Yukon Flats National Wildlife Refuge due to increased human activity and access to this area. There are also spruce grouse and ptarmigan. Songbirds are present and nest in the area. Many species of birds pass through the rail belt Kenai peninsula area during their migration.

Project caused impacts would range from disturbance factors keeping the birds from traditional nesting, feeding, and staging areas to increased harvest because of better access and more people in the area. These effects would eventually cause population reductions. Pollutant spills into waterways and on other bird habitat would also take a toll of the population.

Fish species include rainbow and lake trout, Dolly Varden, char, grayling, burbot, suckers, sculpin, whitefish, and stickleback. The Susitna River system and other streams of the area provide migration routes and spawning and rearing areas for pink, sockeye, chum, coho, and chinook salmon in a decreasing order of abundance.

Cook Inlet fish populations are represented by 25 species of finfish, of which butter sole, yellow fin sole, turbot, and pollock were most abundant. Five species of shrimp, three species of crabs, octopus, scallops, and other invertebrates are also present. Systematic inventories of pelagic species have not been made.

Project-caused effects would include stream blockage because of culverts and other work associated with the project, loss of habitat though silting of stream bottoms, degraded water quality (cooled) because of the cold temperature of the gas under the streambed, aufeis formation, and changing stream channels. Gas chilling stations would cause additional adverse thermal (cooling) impacts. There will also be increased harvest of these fish species because of better access.

Project-caused impacts in Cook Inlet and stream areas from pollutant spills could be a major problem.

The impact of the LNG plant on the shores of Cook Inlet could adversely affect fisheries of the entire area because of effluent dumping, and a heated water discharge could cause habitat and migration route changes to the detriment of the fish populations.

In summary, any of the above mentioned adverse effects would result in a reduction of wildlife populations. In many areas along the route these impacts will be incremental to those already in effect and could cause even greater population losses than if happening in a relatively unspoiled area.

Economic Factors

The primary change from discussions of economic impacts of this alternative system route from those described in Section 8.2.1, Impact Analysis, is that different small towns south of Fairbanks would be affected and that this route passes close to Anchorage and into the one industrialized area of south central Alaska (Kenai).

Impacts on the economy of the State, Native Regional and Village corporations and Boroughs throughout the State have been discussed in the section previously noted.

The impact on Anchorage would be to increase the size of its tax base through greatly increased population and to increase City and Borough spending to service the population, etc.

The impacts on the City of Kenai and the Kenai Peninsula Borough would be similar to those on Anchorage.

A quantitative comparison of economic impacts of the several LNG route variations is possible through an econometric model of the State of Alaska developed by the University of Alaska. A wellhead gas price of $.50 and a production rate of 3.5 Bcf/d produces a wellhead value of $638.8 million, royalties of $79.8 million and a production tax of $25.6 million. For the Cook Inlet route variation, construction employment reaches 7,731 in 1980, including pipeline, marine terminal and liquifaction plant construction; capital investment is $2.8 billion, yielding a property tax of $56.5 million, adding $421.7 million (1958 dollars) to real gross state product, $197.6 million (1967 dollars) to real wages and salaries, and $155.4 million to state revenues. By the time these construction impacts work throughout the economy of the state, their ultimate impact in 1980 includes an addition to employment of 24,500, population 33,600, personal income $567 million and per capita personal income $446 (Scott, 1975).

Sociological Factors

Sociological factors have been discussed in detail in section 8.2.1, Impact Analysis.

Sociological impacts will range from increased cultural improvement opportunities because of a greater demand, to an increase in crime, a lower standard of housing, greater traffic problems, an accelerated rate of decline of Native culture, and an increase of demand for recreational resources, etc.

Because so many more people will be concentrated in the already highly populated Anchorage area, impacts will be multiples of those on the other areas.

Land Use

This alternate system will be built in a corridor already dedicated to transportation or transmission of things. It will be close to a highway or railroad for much of its length, around a major city, and in or close to, an existing gas pipeline corridor.

Detailed discussions of impacts on land use are to be found in Section 8.2.1, Impact Analysis.

Land along the route might be selected by Native Regional or Village corporations under the provisions of ANCSA. This would affect land use planning. Land use planning in the Anchorage and Eagle River Boroughs would have to take into account a major natural gas transmission system. This would affect the number of planners at the Borough level, land use reservations and land commitments.

Historic, Archeological and Unique Area Values

This alternate system would pass a very important archeological site and the possibility is high for further significant finds in the area.

This route lies in the most heavily populated region of Alaska. It is also the most developed area of the state. As a consequence of these factors some archeological surveys and other investigations have been accomplished along the route. The possibility of damage to unknown sites is still quite high.

Potential impacts of the proposed AAGPC pipeline system on prospectively valuable archeological areas include destruction of sites without scientific investigation; destruction after partially completed scientific investigation; vandalism of unexcavated, partially excavated, or accidentally opened sites, and removal of artifacts (surface finds are often of great significance).

It is highly probable that excavation of some sites would be carried out under difficult winter conditions and tight construction schedules. Accordingly, it appears that impacts of this pipeline system would be severe and that there would be destruction of archeological sites, artifacts, or both.

Impacts on the unique areas identified by the Joint Federal-State Land Use Planning Commission in their 1973 Proposal for an Ecological Reserve System for Alaska include:

The impact of pipeline construction on the Ester and Fox Tailings and Easter Dome would be to destroy these study opportunities if the tailings are used as gravel sources for project construction.

Project impact on the Nenana Canyon site might be minimal but the impact of the landslides, etc. may be severe on the project.

Worst project impact on the Susitna Cottonwood site could be destruction of the site through gravel removal for construction purposes or destruction of the vegetation through project-caused fires. Worst project caused impacts on the Susitna River-Montana Creek area would be similar to those listed for the Cottonwood site. Worst project caused impacts on the Campbell Creek watershed site would be to reduce water quality, recreation opportunity and quality, and fish spawning and rearing areas.

Recreational and Esthetic Resources

The area through which this alternate system would pass has undergone much previous development, including a highway and/or railway or construction of a small-diameter natural gas pipeline. The most densely populated area of Alaska lies along the route. With the exception of the pipeline's southern terminal, the impact of gas pipeline construction would not add significantly to the impacts already existing from previous development. Some inconvenience would be imposed on travelers and vacationers while construction is under way.

The critical part of this route is its terminal segment. The development of an LNG plant and of a port and the personnel necessary to construct and maintain these facilities are important considerations.

The Kenai area is already a center of petrochemical development. The addition of personnel involved with construction and operation of this project would add to recreational demand of surrounding areas. Recreational facilities of this area, however, are at presently overtaxed during many of the summer weekends.

The most adverse esthetic impacts of this project will be most noticeable where the pipeline passes close to the proposed gates of the Arctic National Park, Mount McKinley National Park, the area east of Anchorage, and in the recreation areas and streams in the Susitina Basin and the Kenai Peninsula.

Air Quality

Air quality associated with this route varies considerably. Degraded natural air quality has resulted from populated areas such as Anchorage and Fairbanks, industrial developments at Kenai, and natural airborne pollutants in the form of glacier dust and silt associated with the Susitna, Matanuska, Knik, and Kenai Glaciers and rivers. In the unpopulated areas of the Interior Alaska south of Fairbanks and the Mount McKinley area, air quality is usually good.

Section 8.2.1, Impact Analysis, carries detailed information about air quality and project-related impacts on it.

Project operation would have a more serious adverse impact on air quality than construction because of the proximity of roads to the project. If compressor stations are placed near Mount McKinley National Park, Anchorage, or Fairbanks, airborne effluents could adversely affect air quality because of the additive effect. The LNG plant at Nikiska would also add to already degraded air quality in an as yet unknown quantity. Section 8.2.1, Impact Analysis, discusses the probable effects of an LNG plant on air quality.

Environmental Noise

This alternative system is to be placed in a corridor associated with road, railroad, and air transportation for a great portion of its length. Even in the roadless areas of the Kenai Peninsula between Anchorage and the town of Kenai, noise from airplanes, trucks, snow machines, etc. can be heard much of the time.

The addition of construction equipment noise during the summer especially, would have an additive adverse effect on the many people who enjoy recreation in the area.

The placement of compressor stations might be quite critical around Anchorage, Eagle River, Fairbanks, Kenai, Mount McKinley and the Kenai National Moose Range, and on the flats at the mouths of the Knik and Matanuska Rivers.

Impact of compressor station noises would range from disturbing people and/or making some areas of the associated towns unfit for human habitaion, to keeping waterfowl, other birds, and moose from using traditional resting, nesting, feeding, or winter range areas.

Pipeline System Repairs

Because this alternative system will be associated with transportation systems for much of its length, impact of repair activities will not be as major as in other areas. When the pipeline crosses the Kenai Peninsula, impacts of repair activities on the vegetation and soil could be adverse.

Lack of permafrost, a fairly long plant growing season, and fairly stable stream flow regimes, however, would tend to reduce these impacts on soil and vegetation.

Worst case conditions for this line would probably be similar to those described in section 8.2.1, Impact Analysis, except that if the LNG plant at Nikiski would be destroyed the chance of loss of human life would be greater and numbers involved would be greater. The loaded tankers' worst case effect could also have a greater impact on human life and property losses.

8.2.3 Variation: Prudhoe Bay to Haines - Alaska

The portion of the route from Prudhoe Bay to Fairbanks has been discussed in Section 8.2.1.

Description of the Project

This Variation would involve:

1) A natural gas pipeline from Fairbanks to Haines.
2) A natural gas liquefying plant at Haines.
3) Large tanker port facilities for loading gas.
4) Temporary and permanent housing in or near Haines.
5) Increased navigation and communication aids in the Lynn Canal.

This route was considered primarily because it avoided a crossing of the Alaska Range north of Anchorage and paralleled existing highways to Haines in the Alaskan panhandle. This pipeline route would follow the existing Alaska Highway and products pipeline from Fairbanks to Haines Junction, then along Haines Highway to Haines or Port Chilkoot. Construction requirements for the portion of the route between Fairbanks and the Alaskan-Canadian border should pose no unusual problems over those already considered for the primary proposed route. Landsliding, slope failure, avalanches, and mud-rock flows are forms of natural erosion which are common in the southeastern area of Alaska and could pose a threat to pipeline integrity of the route after Haines Junction. The area of Haines is characterized by high seismicity with a history of earthquakes and active faults. There also exist steep unstable slopes and seismically sensitive marine clays that could endanger the pipeline during disturbances.

Total length of the pipeline would be 1060 miles. Compressor stations would be spaced approximately 60 miles apart. Where convenient, and when road access is good, maintenance and construction camps would be sited with compressor stations.

Acquisition of rights-of-way for the route to Haines may be difficult. Unlike many other land ownership patterns for Alaska, most of the route from Fairbanks to the Canadian border is not Federal land. The State of Alaska controls the land over much of the route with the Native villages of Healy Lake, Dot Lake, Tanacross, Tetlin, Northway, and Charlieskin being the other large landowners. The Canadian portion of the route would require the approval of the Canadian government before any route acquisition could begin in that country.

Siting an LNG terminal at Haines or Port Chilkoot provides an ice free port, deep water, and it shortens the tanker shipping route to southern California by approximately 200 miles. Eleven tankers would be needed for the LNG fleet.

Facilities, construction mode, operation and maintenance of a pipeline along this route would be similar to that described in section 8.2.1, Description of the Project.

Description of the Environment

Climate

The climate conditions along this route are essentially the same as those described under the discussion of the continental climate zone and was described in section 8.2.1 for northern section.

The climate of the Haines area border between the wet southeast and the drier interior regions of Alaska. Based on 15 years of record, Haines receives approximately 57 inches of precipitation annually. Climate changes dramatically over a short distance north of Haines, Klukan and Skagway, both approximately twenty miles north of Haines, report considerably drier climate with warmer summer temperatures and considerably colder winters. Temperatures during the summer months at Haines range from 55°F to 80°F. Winter temperatures at Haines are not drastically differnet from those of other southeast towns, generally from 0°F to 40°F, although Klukwan and Porcupine Creek frequently report temperature of 0°F to -30°F.

No specific data exist on destructive storms in the interior area of Alaska. No frequency of occurrence is available on such storms.

Periods of high winds and heavy precipitation occur during winter months in the Haines area. No data are available to suggest the sequence or periods when such events are likely to occur.

Ice fog, as discussed in 8.2.1 is particularly severe in the Fairbanks environs. The cited section makes it clear that this phenomenon is related to any moisture source introduced into a cold atmosphere. Therefore, it is probable that any village or camp along this alternative route could generate locally severe ice fog conditions.

Northwest of Haines, ice fog and blowing snow with continuous cloud cover cause conditions hazardous to travel in the area, especially in the winter. Vehicles traveling between Haines Junction and the Canadian Border area south of Chilkat Pass are often only allowed to travel in convoy with a snow plow.

Topography

This route would cross a number of physiographic provinces. The 8 provinces encountered between Prudhoe Bay to the Alaska-Canadian border have been discussed in detail in section 8.2.1.

From the Alaska-Canadian Border this route would continue to cross the Yukon Plateau for the first 50 miles. From the border to Snag Creek it would traverse unglaciated terrain of moderate relief. Valley floors are poorly drained and marshy. South of Snag Creek the corridor would cross the Wellesly Basin. The floor of this basin is covered by poorly drained glacial deposits. At White River the corridor would leave the Wellesly Basin and drop into the Shakwak Trench. It follows this structural feature to the vicinity of Haines Junction 130 miles southeastward. The Shakwak Trench is 3 to 4 miles wide near the White River, 5 to 8 miles wide near Kluane Lake and about 8 miles wide near Haines Junction. It rises gradually in altitude from 2,400 ft. near White River to 3,100 ft. near Kluane Lake and decreases rapidly to 2,000 ft. at Haines Junction.

At Haines Junction this route turns toward Haines, 160 miles to the south. Through most of this distance the corridor passes through glaciated valleys of the Coast Mountains, crossing Chilkat Pass, 3,300 ft. elevation.

Mountainous slopes adjacent to Chilkoot Inlet, Lynn Canal and Chatham Strait have been modified by alpine and continental glaciation. Masses of ice have carved deep valleys, mantled slopes with till and have helped to form broad alluvial river bottoms reaching to the sea.

Since the last ice age, parts of these lands have been slowly emerging from the sea. Drowned glacial valleys (fjords) are common. Glacial moraines, U-shaped valleys, and other alpine features are exhibited throughout these lands.

Landsliding, slope failure, avalanches and mud-rock flows are common and are forms of natural erosion common to this part of southeastern Alaska.

Elevation ranges from sea level to somewhat over 4,500 feet along the summit areas of the Chilkat Range, and on Admiralty and Baranof Islands.

Geology

From Fairbanks to the Alaska-Canadian border the route strikes through the Tanana Uplands, Tanana-Kuskokwim Lowlands, and the transition zone between them.

Outwash fans grade from coarse gravel near the Alaska Range to sand and silt along the axial streams. Areas north of the axial streams are underlain by thick deposits of "muck," a mixture of frozen organic matter and silt. Parts of the southwestern part of the lowland have thick loess cover, but the central and eastern parts are free of loess south of the Tanana River. Scattered low hills of granite, ultramafic rocks, and Precambrian schist rise above the outwash. Tertiary conglomerate in the foothills of the Alaska Range plunges beneath the lowland in a monocline, and the heads of the outwash fans may rest on a pediment cut across the conglomerate.

The area to the east and northeast of the Chilkat River is underlain by the great diorite belt that makes the Coast Range of mountains. Altered sedimentary rocks, including limestones, slates, phyllites and coarse clastic rocks underlie the western part of the area. There are some small dioritic intrusions in the western part of the area near the Canadian Boundary.

The only mineral production from the Haines area has been from the Porcupine Placer Mining District. Here, gold was discovered in 1898 and productive mining continued until the placer beds were depleted. It is estimated that $10,000,000 (at $175 per oz.) was produced from the district.

Copper mineralization has been found near Kelsall River and in prospects on the ridge between the Chilkat and Chilkoot Valleys a few miles northwest of Haines.

Titaniferous magnetite deposits near Klukwan have been known since 1899. The deposits consist of intergrown magnetite and limonite in pyroxenite surrounded by epidote bearing granite. Both federal agencies and private interests have explored the deposits, but the only ore removed has been for metallurgical testing. Sampling and dip needle surveys suggest the presence of two or three tabular zones. The entire deposit comprises several billion tons of rock containing about fifteen percent magnetic iron. An alluvial fan adjoining the pyroxenite contains an estimated two billion tons of broken rock averaging 10% magnetic iron.

Geologic units to be traversed include frozen ice-rich silts over alluvial gravels from Fairbanks across the Shaw Creek Flats, frozen silt (loess) over bedrock (schist) from the southern end of Shaw Creek Flats to the Tanana River, and generally thawed gravels and sands of alluvial origin from the Tanana River to south of the Border. Permafrost is essentially continuous from Shaw Creek to the Tanana River and discontinuous from the Tanana River eastward to Kluane Lake with some extending to Haines Junction. In the Haines area there is discontinuous permafrost in the high country south of the border grading to permafrost free areas near the coast.

In the frozen zones ice forms include interstitial ice, massive lenses, and ice wedges in the surficial deposits overlying either bedrock or the alluvial gravels.

The entire route southeast of Delta Junction lies within a region of low seismicity (Krinsley et. al., 1971). The closest recorded large earthquakes have occurred about 100 miles northwest of Delta Junction near Fairbanks. Although Gedney et. al. (1972) show a few Richter Magnitude 2 or greater epicenters of earthquakes near the corridor southeast of Delta Junction, their frequency is not great compared to those farther to the northwest near Fairbanks and farther to the south along the Denali fault.

Although Gedney et. al. (1972) suggest that possibly three active faults cross the corridor between Johnson River and Tanacross, detailed field mapping by Foster (1970) does not support this inference. A fault possibly cutting Holocene sediments about 20 miles south of Delta Junction was mapped by Pewe and Holmes (1964), and both these authors and Hamilton (1973) have mapped other faults that cut late Pleistocene deposits along the front of the Alaska Range. It is uncertain whether there is any modern activity along these faults.

From the Alaska-Yukon border to Haines Junction, the corridor parallels or follows the Shakwak fault, an active member of the Denali fault system. In this segment epicenters of earthquakes as large as magnitude 6.5 and of several shocks in the magnitude 5 class have been located within 50 miles of the corridor.

The most severe seismic hazards would probably occur in the Alaskan sector of the route near Haines. This area is a high seismaic risk zone because of (1) possible occurrence of active faults, (2) a history of earthquakes, (3) presence of steep unstable slopes, (4) presence of sensitive marine clays, and (5) tsunami dangers.

The Chilkat River fault parallels the corridor between Klukwan and Haines, and probably lies within 1 mile of it through much of this distance. Current microseismic activity along the fault suggests that it may still be active. An earthquake of magnitude 6, possibly centered on this fault, occurred in Chilkat Valley about 10 miles from the corridor in 1952 (Lemke and Yehle, 1972). Although no other large historic earthquakes have been located close to the corridor, the general Haines region is characterized by high seismicity. Since 1847, more than 100 earthquakes ranging from slight tremors to severe shocks have been felt and reported in Haines.

Soils

Moderately deep and well-drained brown upland soils are most extensive along the route. These are deep and loamy textured in the Fairbanks and Birch-Harding Lakes area, occupying moderate slopes of the highlands. Gravelly to sandy brown soils occupy moderate to steep slopes along the upper Tanana Valley from Big Delta to the boundary, and are shallow to moderately deep over gravelly parent material and bedrock.

Stratified sandy alluvial soils occupy river terraces along the Tanana River from Fairbanks to the Birch Lake area. Wet, loamy soils with a thick overlying peat layer occupy low areas along drainages, extending to low gravelly slopes of the uplands along the upper Tanana.

The unglaciated segments of the corridor from the Alaska-Yukon Border to the White River is characterized by thick residual soils on uplands of the Yukon Plateau and by extensive deposits of loess and muck on the lower slopes and across valley floors. Kettles and other depressions have been largely filled with silt and peat.

From White River to Kluane Lake, much of the Shakwak Trench is floored with thick deposits of late Wisconsin till that has an irregular hummocky to drumlinlike surface in many localities. Smaller streams issuing from the Kluane Ranges have built thick alluvial fans across the floor of Shakwak Trench. Many of the alluvial deposits, especially those of the widely braided White and Donjek Rivers, have been reworked extensively by wind. Sand dunes and modern loess deposits are common downwind from such areas.

East of Kluane Lake, the corridor crosses a complex of alluvial-fan gravels and till, then abruptly enters an area of subdued valley-floor relief underlain by glacial-lake sediments.

Between Haines Junction and the south shore of Dezadeash Lake, the corridor lies within part of the broad basin once occupied by Glacial Lake Champagne. It follows beach deposits through portions of this area, but elsewhere it crosses clayey to silty glaciolacustrine beds. Alluvium also appears to be widespread on the valley floor. Along the west shore of Dezadeash Lake, a series of drift tongues formed by small alpine glaciers extends across the corridor from valleys of the Kluane Range. Relatively unstable bouldery moraines might occur in the drift.

Soil in the Haines area varies from deep alluvium along the streams and rivers to bare rock outcrop at higher elevations. The alluvium consists of boulders, stones, cobbles, gravel, sand, silt and clay in varying proportions. Tidal flats have sedimentary materials that are generally very clayey in texture. Soils on the steeper slope portions vary in depth, texture and rock content. These soils have differing amounts of organic matter accumulation, in places reaching two feet or more of duff at the surface.

Numerous islands dot the channel approaches to Haines. Soils are extremely shallow or non-existent on some of these islands.

Soil parent materials consist of glacial till, sedimentary, metamorphic and igneous rocks and volcanic ash.

Erosion phenomena result from interaction of soil or parent material, as affected by the presence or absence of permafrost, with any disturbing influence, either man-caused or natural. Soils along this alternative will react in a fashion similar, if similarly triggered, as those discussed under other routings.

Water Resources

The route generally follows the valley of the Tanana River crossing the outwash fans of streams entering the Tanana River from the south. The route then crosses the Tanana River near Tetlin Junction and follows the valleys of the Tanana and Chisana Rivers southwestward to the Canadian border.

The Tanana and Chisana Rivers are both gauged by the U.S Geological Survey and data on stream flow are published in cooperation with the State of Alaska.

Flooding and high waters generally occur with the melting of snow each spring, usually in May or June. Periodic high waters and flooding can occur due to storms in the area during the summer months. Runofff in the area is higher in streams flowing north from the Alaska Range than in streams flowing south to enter the Tanana and north flowing streams generally contain higher sediment loads.

The chemical quality of surface waters is generally good. Dissolved solids content ranges from about 75 mg/l (milligrams per liter) to about 500 mg/l. All waters sampled are of the calcium bicarbonate type and are suitable for most uses. The only waters in the area which are higher than the suggested Public Health limits in iron are the lake waters.

The Shakwak trench is crossed by five large, braided rivers: White, Donjek, Kluane, Slims and Dezadesh. Below Haines junction this route would cross the Alsek River.

These Canadian streams contain medium-hard water of the bicarbonate type. Suspended sediment loads are generally less than 70 mg/l in the winter time. Concentrations of sediment are highly variable during the openwater season.

Streams and drainage systems that would be crossed by the route in the Haines area would be the valleys of the Klehini and Chilkat Rivers. The route follows the valleys of these streams and crosses alluvial fans of tributaries, crossing the Chilkat River near Klukwan.

Flooding and peak flows generally occur with melting snow each spring in the months of April or May although periodic high waters may occur throughout the summer due to high rains.

Glacial meltwater adds to the summer runoff and the area has the highest reported sediment loads of the State in streams.

Chemical quality of surface waters in the area are good except for sediment load. Sediment load of the Chilkat River has been estimated to be 12,000 tons per year per square mile of drainage area.

No aquifer systems appear to exist within the State of Alaska which are widespread. Water movement is controlled throughout the State by the geologic structures and movement of water is down stream valley systems.

Movement of groundwater in the Haines area is probably controlled by geological structure and is primarily down the valleys of the major streams of the area. Little data are available on the quality of ground water in the upstream areas away from Haines. It is believed to be of good quality and generally low in dissolved solids. At Haines deeper wells may encounter saline waters, shallow wells produce calcium bicarbonate type water with low dissolved solids content.

Water is drawn for use from ground water sources, mainly alluvial sources, at only a few places along the pipeline route. Use is only for individual or small town supply and is low.

The principal aquifer being tapped for water along this alternative route is the alluvial aquifer along the streams.

Ice jams and flooding may also occur in major rivers in Alaska in the spring since river ice (usually several feet thick) does not always break up uniformly and may accumulate in unfrozen reaches in areas of constriction, or in the shallows.

Channel scour shifting of stream chemicals, and lateral erosion occur continuously throughout a flood plain, but may be accelerated greatly by icings or ice-jam flooding. Major floods, including outburst floods, can cause channel scour and subsequent deposition to unusual depths. In many streams, bed materials are more resistant to scour than are bank areas, especially when the beds are protected by a channel armor layer. This is especially true in meandering streams. During floods, water tends to erode upstream-facing margins of meanders and deposit materials on the opposite margins. Occasionally, flows breach the necks of meanders and form new channels.

Ice jam flooding is generally restricted to larger streams such as the Yukon, Tanana, or Chilkat Rivers. To the south near the Alaska Range, the pipeline route passes near small glacier-dammed lakes which have potentials for outburst flooding.

Flooding usually occurs with breakup in May or early June, but periodic flooding can occur at any time during the summer.

Vegetation

Eight vegetative types are traversed from Prudhoe Bay to the Canadian border via this route. Approximate percentage is as indicated below:

Vegetative Type	Approximate % of Alternative Route
Wet Tundra	2
Moist Tundra	11
High Brush	10
Alpine Tundra	9
Upland Spruce - Hardwood Forest	34
Low Brush, Muskey - Bog	4
Bottomland Spruce - Poplar Forest	13
Lowland Spruce - Hardwood Forest	17

All types have been previously described in Section 8.2.1, Description of the Environment. It is important to note that the tree species types are more productive at lower latitudes along this route.

In Canada the route would traverse boreal forest. The vegetative types encountered would be the same as those above. After dropping down out of Chilkat Pass this route would enter the wet coast forest.

In the Haines area, the vegetative type is the Coastal forest. This type is primarily forest vegetation with a uniformity of species. Western hemlock(Tsuga heterophylla) and Sitka spruce Picea sitchensis) are the dominant trees. Sitka alder Alnus crispa subsp.sinuata), willows (Salix spp..), black cottonwood (Populus balsamifera L.) various forbs, grasses and sedges grow on the more moist sites at lower elevations. Revegetation of most of these soils following disturbance is rapid.

The recently constructed TAPS road has made a significant impact along the right-of-way. Normal road construction activity has resulted in roads, stockpile site, camp areas, etc., destroying the natural vegetative areas. The Fairbanks to Haines segment would follow existing highways and have the usual impacts associated with human development. Small farms, business enterprises, residences have destroyed or changed the vegetation.

There is a direct relationship between the degree of accessibility of any given area and the amount of vegetative disturbance. Although this disturbance is very noticeable and pronounced, the percentage of such land is quite small when compared to the corridor width.

There are no known vegetative species whose existence is threatened by this route.

Although all vegetation zones crossed by the proposed pipeline route are subject to fire, they differ in their ability to carry a fire, once it has begun.

Man caused fire potential exists mainly during the period of May through September. The exception will be the deep burning winter camp, warming, or other fires that reach peat beds of sufficient mass to sustain fires through winter months. These fires will burn to the surface and ignite surface fuels during the summer months.

Man caused fire ignition is a particular problem on this route where there is currently a land transportation system established. Pipeline related activity on established transportation routes and the establishment of additional routes would increase the ignition sources and result in additional fires.

Wildlife

A detailed discussion of wildlife in Interior Alaska is carried in section 8.2.1, Description of the Environment. The wildlife along the Canadian segment is typical of the boreal forest. The general discussion in the above cited section applies.

Except in locations contiguous to the various communities indicated above, wildlife is present in its natural state throughout the area that the route will traverse. Mountain goats are very abundant along the whole Lynn Canal. Winter range is very important to maintenance of goat populations and in an area with steep side slopes such as Lynn Canal, the goats winter in areas adjacent to the beaches rendering them particularly vulnerable to excessive hunting pressure.

This area supports all of the big and small game types, including moose and Sitka black-tail deer, found in Southeastern Alaska. The Endicott River system contains significant numbers of moose.

Both the Chilkat Basin and the Klehini are recognized for the numbers and size of bear they produce. Sitka black-tail deer are observed in the Chilkat Lake area and in the Lower Chilkat River Valley. Mink, marten, land otter, ermine and wolverines constitute the important furbearers.

Waterfowl use the profusion of ponds and marshes throughout the Chilkat Basin. The ducks seen during summer and fall surveys are listed in order of observed abundance: mallard, widgeon, green-winged teal, merganser (both American and hooded), scaup, pintail, bufflehead, American goldeneye, and shoveller. According to local residents, Canada geese were less abundant this year than in recent years, but only mallards were observed more frequently than geese by survey personnel. The 1960-61 survey crews of the Fish and Wildlife Service received reports of several small flocks of snow geese passing through the Basin. A flock of about 15 swans was also reported but only one was seen on two occasions in the upper Basin by survey personnel.

Bald eagles are found in considerable abundance in the Chilkat Basin, and the fall and winter concentrations along the Big Salmon Delta were noted previously. The nests of these birds are quite common, particularly in the valley above Wells' Bridge.

Of unique significance is the concentration of bald eagles which occur along the lower Chilkat in October and November, reported to be the greatest in the world. In 1970, over 3,500 were counted in a 2-mile stretch - one cottonwood tree was reported to have 56 perching birds.

Most of the streams and rivers carry various types of trout as well as runs of spawning salmon during various times of the year, and the waters of Lynn Canal have been a major commercial and sport fishing location for over fifty years. The Chilkat, Sullivan, Endicott, and Beardslee Rivers and "Snug Cove" Stream are major fish streams; however, the combined spawning runs in the other streams are significant to the overall escapement of salmon in the waters of Lynn Canal.

All five species of salmon--pink, chum, coho, sockeye and king--utilize the area. Production of salmon is important, contributing substantially to the local economy as a result of the gill net, seine, and troll fishery. Dolly Varden, cutthroat and steelhead as well as salmon are equally sought by sport fishermen.

The Chilkat River supports significant runs of chum salmon that occupy spawning areas all along the Haines Cutoff Highway from about August 1 to December 1. The eggs incubate until May and the young chum salmon migrate downstream to saltwater soon after hatching.

Socio-Economic

By the 1880's trading posts dealing with fur and fish had been established at the present settlements of Dawson, Forty Mile, and Eagle. In 1905, construction of a system of country roads, winter sled roads, and trails was begun, with Fairbanks as the center. Adolphus W. Greely, of the Signal Corps, began construction of the land line in 1901. Telegraph lines were constructed to connect all the main cities of the Yukon Valley, Bering Straits Region, and southeastern Alaska. The village of Tanacross originated as a telegraph station where the telegraph lines crossed the river.

The construction of the Alaska Highway during World War II and the paving of the Glenn and Richardson Highways in the early 1950's has had a profound effect upon the communities along its route as far as Fairbanks. All Fairbanks-bound (and all Anchorage-bound from the border to Tok) freight and passenger traffic from the Alaska Highway passes through this region.

Haines-Port Chilkoot originally was a trading post for both the Chilkat and Interior Indians. A trading post was established in 1878, a mission founded in 1881, and a post office established in 1884. The town became an important outlet for the Porcupine mining district which worked the beginning of the Dalton Trail. A military post was established at Port Chilkoot, to the south of Haines, in 1904.

Trapping activity has been on the decline since World War II. Fur prices did not rise for many years due to competition from synthetics and ranch furs.

The communities considered in these pipeline segments are in two Native regional boundaries. In the Boyon Native region are the communities of Delta Junction, Bot Lake, Tanacross, Tok, Tetlin, Northway. All but Delta Junction and Tok are predominantly Native. Tetlin has elected to be outside the structure of Doyon, Inc., electing to choose the Tetline Reserve under the terms of the ANCSA. In the Sealaska Native Region are the communities of Haines (predominantly non-native) and the Native community of Klukwan.

Delta Junction is a second class city and can, with the consent of the people, have property, sales, and use taxes. Second class cities have planning and zoning powers that would provide regional planning services for local areas. The Native entities of Dot Lake, Tanacross, Tetlin, and Northway operate under traditional or Indian Reorganization Act councils. All of the above communities are in an unorganized borough. The principal Canadian communities along the route are Beaver Creek and Haines Junction. Service centers for travelers can be found at Destruction Bay and a number of lodges.

Haines is a first class city and along with Klukwan is in the Haines (third class) Borough. Also, the Natives in Haines and Klukwan were chartered under the Indian Reorganization Act in 1941.

The area has the physical characteristics, wildlife, and a road system to attract tourists from within and outside Alaska.

Haines and Klukwan are in the southeast forest habitat and at the head of the inland waterways. The Tetlin Reserve also is strategically located. All motor traffic from the states through Canada or by way of the northern Alaska ferry terminal at Haines must travel through the Reserve. Attractions and potentials are varied and encompass general outdoor recreation, a wealth of natural environment, primitive areas, Natives and their communities.

Large low grade iron deposits are located in the vicinity of Klukwan and development of this resource is beginning. U.S. Steel has a 10-year lease ($50,000) on the alluvial fan of iron along the Chilkat River.

Prior to 1963, Haines underwent periods of prosperity and recession based on varying annual salmon catches and construction activity. Establishment of a woods product industry since then has provided more stability. Oil pipeline activity since 1973 is resulting in a large increase in transients enroute to Fairbanks (or returning) which is presently causing some disruption. Since 1967, timber has become the major industry. Regular growth and private investment have proceeded in the last decade.

Total 1972 employment in the Haines area averaged 1,557 annually with a 13.9% unemployment rate.

The population of Haines in 1970 was 463, which does not include an uncounted number outside of the town.

Native Subsistence

The communities of Wiseman, Evansville/Bettles, Stevens Village, Minto, Tanacross, Dot Lake, Tetlin, Healy Lake, Northway and Klukwan are the native villages that would be encountered along this route. The inhabitants of these villages depend, for the most part, on the natural resources of the area for their subsistence. Those villages that are served by ground transportation are trending toward a cash based economy but this is not the dominant means of subsistence at this time.

Land Use

Land use from Interior Alaska has been previously discussed in Section 8.2.1, Description of the Environment. Land use for east central interior Alaska and the Haines area follow.

Present use for agricultural purposes along the interior portion of this route is limited, but the potential for use of 3 areas of uplands south of the Tanana River is relatively good. The forestry resource in the area traversed by this route is considerable. Bottom-land spruce and birch stands are found on the flood plains and river terraces along the Tanana River. The forest inventory has been conducted in the subregions, but data are not applicable because they apply to the entire sub-region. Growth rate in regeneration appears adequate but most stands are understocked and could produce more volume if intensively managed.

There is no agriculture being carried out in the Haines area except for personal gardens. There is some agricultural land available.

There is sufficient timber in the Haines area to support the two sawmills already working in the area. Potential for developing further timber related industry is good on the nearby State and Federal Forests.

South of Fairbanks this route is along historic transportation routes as established by the construction of the Alaska Highway during the Second World War, the Haines cut off which connects Haines and Southeastern Alaska with the Alaska Highway at Haines Junction.

An 8-inch cold fuel pipeline currently exists along this route. The pipeline was constructed in 1954-1955 by the U.S. Army to transport refined petroleum products from Haines to Fairbanks. Recently the 432-mile segment from Haines to Tok was deactivitated.

There are no industrial areas, (per se) along the route. The most visible industry along this route is the summer tourist and recreation business.

Deep water port facilities for the Haines-Port Chilkoot area are located on Lutak Inlet, five miles by highway to the north of Haines. Anchorages with good holding ground may be had in 40 fathoms 2.5 miles from the head of the inlet.

The U.S. Army POL (petroleum-oil-lubricants) dock on the south side of Lutak Inlet has about 750 feet of berthing space. The U.S. Army dry cargo marginal wharf with a 1,000 foot face is about 0.5 miles westerly of the POL dock. In 1963, depths of 44 feet were reported alongside both docks. In 1963, Haines was connected by the Alaska Marine Highway System to all major communities in Southeast Alaska and Prince Rupert, B.C.; the ferry terminal is east of the dry cargo dock. Approach routes from the ocean are deep-water.

The land ownership pattern for this route is unusual in Alaska, in that most of the land is not Federal land. The State of Alaska selections and patents cover most of the route with the other large land owner being the Native villages of Healy Lake, Dot Lake, Tanacross, Tetlin, and Northway.

The classification process for the State lands along the route has not yet been completed. The withdrawal for the native villages is still intact, as the Native Regional Corporations have one year in which to select lands and these regional corporations may select from the land not selected by the villages or from deficiency areas that lie within that native region.

From Northway Junction to the Alaska-Yukon border the route would traverse the proposed Wrangell Mountains National Forest.

This route has a past history of relatively intensive settlement claim activity, due to the ready access provided by the Alcan Highway. The majority of the settlement claims are homesteads or native allotments. Other settlement claims are headquarters sites or trade and manufacturing sites.

A considerable number of agencies and organizations may be involved in land use planning for the general areas along this route: The Doyon and Sealaska regional corporations and their village corporations; the Indians of the Tetlin Reserve; State Division of Planning and Research; State Department of Community and Regional Affairs; various federal agencies concerned with Native people, land management, wildlife refuges, and the National Systems; the Haines Borough; the first class city of Haines; and the second class city of Delta Junction.

Archeological, Historical and Unique Areas

Early in the planning for the oil pipeline the predecessor of Alyeska Pipeline Service Company, as applicant before the Department of the Interior for a right-of-way, was required to initiate an archeological survey of the route. Following what became one of the largest archeological inventories in the history of North America, The Final Report of the Archeological Survey and Excavations along the Alyeska Pipeline Service Company Pipeline Route was published in 1972.

The route from Big Delta to Haines was not described in the above mentioned report. In 1974, Archeology and History Along Alaskan Natural Gas Routes was published, which describes sites along the roure from Big Delta to Haines.

The route from Big Delta to the Alaskan-Yukon border passes near two of the most important arcgeological sites in Alaska. The Dixthada Site contains a long and more or less continuous sequence connecting historic and prehistoric Athabaskan material culture. The Healey Lake Site contains the earliest radiocarbon dated level in Alaska. Historic sites include camps, mines, posts and the Valdez-Eagle Trail.

There are 14 known prehistoric sites for the segment of the route from the Alaska-Yukon border to the British Columbia-Alaska border. These sites represent a rather complete cultural sequence for the Southwest Yukon. The discovery and excavation of R1,JhVq-1, the Gladstone site, and R2,JiVs-1, the Little Arm site, have brought to light data of immense archeological importance. These two sites in themselves exhibit evidence of six cultural phases spanning a period of 10,000 years, which have been identified by characteristically unique tool inventories. The other 12 known sites represent components of the district cultural phases identified at the Gladstone and Little Arm sites. These cultural complexes are manifestations of larger, distinct ways of life persisting in time and space, called traditions.

The sites that are near to the route are:

R6, The Christmas Creek

R11, Site 1085

R12, Site 1081

R13, Site 1074

R4, JI Vs-4

R3, JiVs-3

R9, Jc Ve - 1

R10, JeVi - 1

The area along this segment of the route was the scene of the gold rush era of 1897 to 1898. The route is rich in evidence of early English and French speaking traders, missionaries, trappers and Native cultures.

There are no recorded archeologic sites near the route from the British Columbia-Alaska border to Haines.

This segment contains significant information regarding the history of the State of Alaska. The Klondike, the Trail of '98, Chilkoot Pass, White Pass, the Yukon Railroad, Skagway, Dawson City, the Dalton Trail, Lynn Canal, Haines, Klukwan, and Porcupine, among many others, are places that have notable influenced the historical development of both the immediate area and the interior of Alaska.

This segment presently has two sites on the National Register of Historic Places, Pleasant Camp Post on Mile Forty-two of Haines Highway (SKG 002) and the Skagway Historic District and White Pass, at the head of Taiya Inlet on Lynn Canal.

Recreational and Esthetic Resources

This gas pipeline route would follow the Alaska Highway from Fairbanks to the Haines Junction and the Haines cut off to Haines. The Alaska Highway is a major access route to Alaska from the east and the Haines cut off from the south.

The Alaska Highway corridor from Koidern to the Tatshenshini River, both in Yukon Territory, which the pipeline route would follow, parallels and, at times crosses the eastern boundary of the Kluane Territorial Game Sanctuary. From the southern end of Kluane Lake to the Tatshenshini River, both in Yukon Territory, the pipeline route would parallel and at times cross the eastern boundary of the Kluane National Park (established in 1972). The Kluane Territorial Game Sanctuary (10,130 square miles), within which the 8,500 square mile Kluane National Park lies, extends west from the Haines corridor to the Alaska-Canada border and south to the British Columbia-Yukon border. The St. Elias Mountain Range (North America's highest range) covers most of the sanctuary and park and massive ice fields and unique wildlife populations are contained in this area.

Haines is currently the principal jumping-off point for recreationists entering the interior of Alaska via the Alaska Marine Highway system. Subsequently many of the town's facilities are geared to the tourist and much of its economic base is derived from tourist-oriented services. This is true of development all along the route as well. Summer use is substantial, particularly when considering the seasonal backlog of southbound visitors awaiting ferry transportation.

The following are the established recreational areas between Tok and Haines in Alaska only:

Moon Lake Wayside - 92 acres; Tok
Camping, swimming, boating, canoeing

Gardiner Creek Wayside - 10 acres; Tok
Camping and fishing

Deadman Lake Wayside - 20 acres; Tok
Camping, boating, canoeing, fishing & swimming

Lakeview Wayside - 415 acres; Tok
Camping

Tok River Wayside - 4 acres; Tok
Camping, boating, canoeing and swimming

Eagle Trail Wayside - 640 acres; Tok
Camping, hiking, fishing

Porcupine Creek Wayside - 240 acres; Tok
Camping

Mosquito Lake Wayside - 5 acres; Haines
Camping

Chilkoot Lake Wayside - 80 acres; Haines
Camping and fishing

The rugged highlands of the Coast Mountains, the Takhinsha Mountains and the Chilkat Range which surround Haines are for the most part defacto wilderness areas in view of their remote and rugged character. No wilderness study proposals have yet been considered for areas adjacent to Haines either on state land or on lands managed by the Forest Service. Glacier Bay National Monument, proposed by the National Park Service as a wilderness area under the Wilderness Act of 1964, is approximately 80 air miles southwest of Haines.

Air Quality

Air quality along this route will be similar to that described in Section 8.2.1, Description of the Environment, because major portions of both routes are the same and in dissimilar portions they both follow established transportation routes to the sea coast.

Environmental Noise

The comments that were made for air quality apply to this segment also.

Impact Analysis

Summary of Major Impacts

1) Climatic conditions such as extreme cold, blowing snow and ice fog could cause delays in construction and maintenance schedules and, at times delays in repair activities.

2) Permafrost, frost heave and slope stability, particularly in ice rich soils could affect the construction and integrity of the pipeline. South of Chilkat Pass mass wasting hazards are high due to the heavy snowfall on the windward side of the Coast Mountains, the precipitous mountain slopes in direct contact with the pipeline and the widespread marine clays near Haines.

3) High Seismic and mass movement risk exist at the southeast end of Kluane Lake at the Slims River crossing where the pipeline enters the Shakwak fault zone. This condition could have major impacts on the construction and integrity of the pipeline.

High seismic risk in the Haines area. Earthquakes could cause translatory or rotational slides in the marine clays near Haines and also the risk of tsunamis are significant in this area.

4) The potential of frost bulbs forming around the pipeline at stream crossings is significant in relation to the number of streams crossed. Twenty-nine major streams are crossed. Frost bulb formations could change the flow regime and cause channel changes that would have an adverse impact on manmade facilities near the pipeline.

5) The addition of toxins and pollutants and the withdrawal of water related to construction and maintenance operations would have a major impact on the ecology of areas adjacent to the pipeline.

6) There would be a favorable impact to land use as the route follows existing transportation corridors the whole way.

7) Little is known about the archeology of the Haines alternative. While construction of the pipe would destroy potential archeological sites it could also uncover some sites. The construction activities would have a major adverse impact on two of the most significant archeological sites in Alaska, the Dixthada and Healey Lake sites. Only two historical sites are on the National Register, SKG002 Historic District and White Pass, but the route traverses areas rich in history.

8) The socio-economic impacts to the major population centers of Fairbanks, and on a lesser scale Haines, are both beneficial and adverse. The beneficial impacts would be: an increase in trade to local businesses; an increased tax base for cities and an increase in cultural activities. The adverse impacts would include: inflation; crowding of schools; a shortage and lower standard of housing; an increase in crime; and an acceleration in the decline of Native culture.

9) The pipeline would impact the Kluane National Park, in Yukon Territory, as it passes close to and at times transects its eastern boundary. The route would also have an impact on the Kluane Territorial Game Sanctuary in Yukon Territory, as it parallels its eastern boundary. These impacts and others are analyzed in greater detail in the following analysis.

Many of the impacts of this route will be similar to those described in Section 8.2.1, Impact Analysis. Where this is true only reference to that route will be made. Different environmental impacts will be listed.

Detailed Analysis

Climate

See Section 8.2.1, Impact Analysis.

Topography

See Section 8.2.1, Impact Analysis.

Geology

Areas subject to erosion and mass wasting under natural conditions are identified below. Most of these same areas would be subject to accelerated slope processes as the result of pipeline-related activities. Additional areas of concern would be these:

1) Moraine belts near Johnson River and Robinson River, if clayey, silty till is abundant here.

2) Colluvial slopes between Johnson River and Tanacross, particularly where these are being undercut and steepened by lateral cutting of the Tanana River near Cathedral Bluffs.

3) Landslide deposits 5 miles west of Tanacross.

4) Areas of shallow, ice-rich permafrost between Paradise Hill and the international boundary.

5) Steep narrow glacial valley segments between Three Guardsmen Pass and the international boundary; and

6) Areas of elevated marine clays near Haines.

High seismic and mass movement risk exist at the southeast end of Kluane Lake at the Slims River crossing where the pipeline enters the Shakwak fault zone. Here the pipeline would be forced against the base of steep, potentially unstable mountain slopes accentuating seismic risk through the possibility of vibration-triggered sudden mass movements. Special earthquake design considerations would be required in this area.

Anticipated effects of strong earthquakes in the Haines area would include (1) surface displacement on faults; (2) ground shaking; (3) compaction, subsidence, and fracturing of sediments; (4) liquefaction of saturated sands and silts; (5) flowage of sensitive marine clays; (6) subaerial slides and slumps; (7) subaqueous slides; and (8) tsunamis, seiches, and other abnormal water waves (Lemke and Yehle, 1972, p. 67-90). All of these hazards would have an adverse impact on this pipeline within the Haines area.

For other geologic impacts see 8.2.1, Impact Analysis.

Soils

See Section 8.2.1, Impact Analysis.

Water Resources

See Section 8.2.1, Impact Analysis.

Vegetation

This route should have little direct impact on the vegetation in the Haines area. Emissions of nitrogen oxides and sulfur dioxide fumes by the proposed LNG plant and tanker ships plying the Chatham Strait-Lynn Canal route to Haines could affect vegetative respiration, but the anticipated concentrations indicate insignificant levels of density.

The most likely impact would be the increased local demand for forest products due to the increased population associated with the development of Haines. This would probably mean increased consumption by the two sawmills in Haines and increased use of the nearby forest for firewood, house logs, etc., by the local population. Most forests adjacent to Haines are state-owned and they would absorb much of the individual use demands.

Wildlife

See Section 8.2.1, Impact Analysis.

Socio-Economic

See Section 8.2.1, Impact Analysis.

The impact upon Haines from construction of an LNG Plant and shipping facilities would be similar but greater because of closeness than that described for Cordova.

A quantitative comparison of economic impacts of the several LNG route variations is possible through an econometric model of the State of Alaska, developed by the University of Alaska. A wellhead gas price of $.50 and a production rate of 3.5 Bcf/d produces a wellhead value of $638.8 million, royalties of $79.8 million and a production tax of $25.6 million. For the Haines route variation, construction employment reaches 7,440 in 1980, including pipeline, marine terminal and liquifaction plant construction; capital investment is $3.1 billion, yielding a property tax of $63 million, adding $292 million (1958 dollars) to the real gross state product, $202.5 million (1967 dollars) to real wages and salaries, and $163.3 million to state revenues. By the time these construction impacts work throughout the economy of the state, their ultimate impact in 1980 includes an addition to employment of 24,300, population 33,500, personal income $581 million and per capita personal income $477 (Scott, 1975).

Land Use

The construction, operation and maintenance of a large diameter natural gas pipeline and associated liquefaction plant located in the vicinity of the Tongass National Forest will have significant collective impacts on this management unit. There will be overall impacts on the resources and amenities found on the Forest lands, as well as upon the funding, administration and management of the Tongass National Forest. These impacts would also be felt in the proposed Wrangell Mountains National Forest.

The socio-economic impact on Haines and South East Alaska will in turn cause some of the greatest impacts on the administration and management of the Tongass National Forest.

Administrative Impacts--Due to a greatly expanded community population in such a short period, an increase in demand on the Tongass National Forest for goods and services will occur that probably will be beyond the present level of manpower, funding, and planning capability to provide.

1) Additional recreation planning, facilities, and maintenance would be needed.

2) Administration of common variety mineral applications for construction would increase.

3) Special use permit requests and administration would increase.

4) Increases in development and administration of easements and land exchanges would occur.

5) Increased engineering services for access roads, communications, housing, storage facilities pollution abatement, fire control, etc. would be required.

6) Special stipulations which may apply to Tongass National Forest lands, over and above the various Forest resource values will have to be developed.

7) Coordination and agreements with pipeline and LNG plant. Operators, other Federal and State agencies, and adjacent land owners may be required to assure the best possible interrelationship between the pipeline construction and operation, and the management of the Tongass National Forest's and region's resources. This would be especially true in areas where the pipeline corridor, LNG plant or associated facilities affect high value recreation areas, major wildlife sites, or other environmentally sensitive areas requiring special resource protection or management.

8) Congestion of public transportation may restrict Forest Service use and activities.

See Section 8.2.1, Impact Analysis, for other Land Use impacts.

Archeological, Historic and Unique Areas

See Section 8.2.1, Impact Analysis, for impacts not discussed below.

There are areas of archeological importance along the Haines route. The corridor from Delta Junction to Beaver Creek contains two of the most significant archeological sites in Alaska, the Dixthada Site and the Healey Lake Site. These sites are notable for the early time periods they represent and for the richness of the cultural material present. Additional sites of this caliber may be encountered within the segment of the corridor running through the Yukon. Fourteen sites have been located. These sites contain evidence of unique cultural adaptations spanning a time period of some 10,000 years. Although there has been excavation of sites located in this area, there is every reason to believe that many as yet undiscovered sites remain to be found. There are no recorded archeologic sites along the corridor from Pleasant Camp to Haines.

The importance of the archeological resources along this route cannot be overemphasized. The choice of this alignment would require careful planning in order to protect both known sites and unknown sites from destruction.

Although there are only two historic sites on the National Register within the Haines route (SKG002 Skagway Hstoric District and White Pass), it should be noted that the corridor passes through areas that are extremely rich in evidence of early French and English traders, missionaries, miners, Native cultures and trappers. These areas have a great potential for further discovery of historically significant sites that are quite likely to be nominated to the National Register.

Recreation and Esthetics

See Section 8.2.1, Impact Analysis, for the Alaska portion. The impact of the pipeline on the Kluane Territorial Game Sanctuary (Yukon) and the Kluane National Park (Yukon) would be major. Both areas are designated for limited development. The game sanctuary and park do not allow hunting and the game sanctuary still allows mining activities. The construction and maintenance activities would have adverse effects on both the wildlife and recreational values of the park and sanctuary. Esthetic wilderness qualities would be threatened, and wildlife habitats would be damaged along the route. Due to the highway, the sections of the park adjacent to the pipeline route are intensively used by recreationists.

Air Quality

See Section 8.2.1, Impact Analysis.

Environmental Noise

See Section 8.2.1, Impact Analysis.

8.2.4 Variation: Prudhoe Bay to Golovnin Bay - Alaska

Description of the Project

This natural gas transmission system route would be from Prudhoe Bay to Golovnin Bay on the southern shore of the Seward Peninsula and is an alternative routing for the pipeline/LNG tanker combination mode. Sea ice is seasonally present in the Bering Sea portion of this route.

Location of a LNG plant and marine terminal at Golovnin Bay would require a gas pipeline route with the following general description: it would parallel the Alyeska Oil pipeline corridor south from Prudhoe Bay for approximately 50 miles, then turn westerly near the confluence of the Ivishak and Sagavanirktok Rivers, proceeding across the Brooks Mountain Range. At approximately 154° west longitude and approximately 40 miles above the Arctic Circle, the route would turn in a more westerly direction crossing the Zane Hills, and generally paralleling the Huslia River. From there, the route crosses the southeastern portion of the Seward Peninsula to Golovnin Bay on Norton Sound (See Figure 8.2.1.-2).

The length of the Golovnin route would be approximately 750 miles. The basic design, description of facilities, construction scheduling and procedures, presented in 8.2.1 is generally applicable to this alternative route. Compressor stations would be spaced approximately 60 miles apart.

This variation would cross approximately 900 miles of the Bering Sea and would lengthen the shipping route to Southern California by approximately 1100 nautical miles. Eighteen tankers would be needed for the LNG tanker fleet.

Description of the Environment

Climate

For a Description of climate north of the Brooks range see Section 8.2.1 Description of the Environment. Climatic data for the interior and northwestern area of this route is limited in scope.

This area is dominated by a sub-arctic climate characterized by great temperature variations daily as well as annually, combined with generally low precipitation and surface winds. Diurnal temperatures here range from an average 0°F to -10°F maximum and -20°F to -30°F minimum during the coldest month (January) to an average 65°F to 70°F maximum and 42°F to 47°F minimum during the warmest month (July). Mean annual temperatures average 15°F to 25°F Absolute extremes have ranged from the minus 70°'s F in winter to the low 90°'s F in summer, with the greatest extremes of both heat and cold occurring at the lowest elevations. Winters are long and bitterly cold. In contrast, summer temperatures are surprisingly pleasant, with 30 to 40 days each year reaching a maximum of 70°F or higher (Watson, 1971).

Precipitation amounts are light, averaging from 12 to 18 inches annually in the Mt. Igikpak region west of the Alatna River, and from 8 to 12 inches over the slightly drier Mt. Doonerak region to the east. Measurable precipitation occurs about 100 days out of each year. Snow falls normally in 8 to 9 months of the year, averaging between 60 and 80 inches each season. Depending on exposure, localities receive slightly more or less snow than this. In all areas, however, the snow has a light, dry consistency. The three month period from late June to early September is the wettest time of the year, receiving over half the total annual precipitation. Thunderstorm activity is relatively frequent for latitudes this far north, with each location averaging between five and ten thunderstorms each summer. Thunderstorm intensities are generally mild; they occur mostly during June and July.

Surface winds at lower elevations are for the most part light throughout the year. Prevailing wind directions are influenced to a great extent by the terrain. Only on rare occasions will wind speeds exceed 35 mph or 45 mph, and these are limited mostly to a local funneling effect.

Weather records from Wales, Nome, and Unalakleet suggest the probable weather conditions that could be expected at the port site. Mean annual temperatures range from 21°F to 26°F with extremes ranging from -60°F to 86°F. Annual precipitation range is 11.3 inches to 27.0 inches with average cumulative snow depth ranging from 40 inches to 54 inches.

See discussion on the marine environment of the Bering Sea for detailed information on the characteristics of the sea ice.

Ice fog is a phenomenon peculiar to arctic and subarctic regions. While normal fogs are concentrations of water droplets, ice fogs are one step beyond--the water has frozen. Three factors are necessary for ice fog to form: (a) a temperature lower than -25°F, (-31.6°C); (b) a source of water, and (c) particulates in the air that form nuclei for droplet and ice particle formation.

Ice fog is not restricted to urban areas. Hot springs, cooling ponds, open salt water leads, and construction equipment all are adequate sources of vapor. The latter also emits particulate matter. Without winds to dissipate it, ice fog often is confined to narrow stretches, or patches over a source of moisture where it remains in situ until the inversion lifts.

Ice and regular fog are frequent along the Bering Sea coast and with the light winds may be quite persistent.

Topography

This alternative route crosses four physiographic provinces besides those described in 8.2.1 Description of the Environment.

These units are Kokrine-Hodzana Highlands, Kanuti Flats, Kobuk-Selawik Lowland, and Seward Peninsula.

The proposed route extends roughly 450 miles west and then southwest from Prospect, starting on the western edge of the Kokrine-Hodzana Highlands.

Kokrine-Hodzana Highlands

This segment of the route is the shortest. The route starts on the western flank of the highlands, the slope draining toward the Koyukuk River. The Highlands consist of even-topped rounded ridges rising to 2,000 to 4,000 feet in altitude, surrounded by isolated areas of more rugged mountains. Valleys have alluviated floors to within a few miles of their heads.

The highlands are underlain chiefly by Paleozoic and Precambrian schist and gneiss having a northeast-trending structural grain, cut by several granitic intrusions.

This route is underlain by unconsolidated deposits consisting of frozen colluvial silts, sands, and rock fragments, glacial sand and gravel, and stream sand and gravel.

Much of the area is underlain by ice wedges and lenses. In local areas ice wedge polygons, solifluction lobes, and ice lenses occur.

Kanuti Flats

The Kanuti Flats form an irregular shaped lake-dotted plain 400-1,000 feet in altitude that merges with low surrounding hills. Scattered low irregular hills rise in the central part of the plain. The route passes westward across the flats area in an east-west trending glaciated valley. This portion of the route is believed to be underlain by thick deposits of colluvial and glacial sand and gravel, all of which is frozen, except where large lakes or rivers exist. In this portion of the route several of the northern tributaries of the Koyukuk River are crossed by the route.

After leaving the Kanuti Flats area the route turns southwestward and enters the Kobuk-Selawik Lowland unit. In this portion the route crosses the eastern edge of a lake-dotted plain. Scattered hills rise to the east. This segment of the route crosses the headwaters areas of the Kobuk River and several other smaller streams draining into Kotzebue Sound. This portion of the route is believed to be underlain by colluvial silts, sands and gravels, glacial sands, and gravels and thawed stream deposits. Most of the ground along this segment, except those areas near streams, is frozen and probably contains some areas of fine-grained ice-rich deposits and solifluction lobes.

The western segment in the Lowland unit follows another narrow valley stream probably underlain by thick deposits of colluvial and glacial deposits of silts, sands and gravels. Several streams are crossed in this segment of the route, all of which drain to Kotzebue Sound. The entire area is underlain by permafrost and may contain ice wedges, lenses and solifluction lobes.

Seward Peninsula--This portion of the route crosses the lowland portions of the southeastern Seward Peninsula. Relief along the route ranges from sea level to more than 2,000 feet in altitude. The right-of-way is believed to be underlain chiefly by silts, sands and gravels of glacial and colluvial origin although some bedrock areas of Paleozoic schist, gneiss, and metamorphosed volcanic rocks may be crossed. Structural trend of the metamorphic rocks is chiefly northward.

The entire area of this line segment is underlain by permafrost where some fine grained ice-rich sediments and ice-wedge polygons, solifluction lobes and ice lenses will be found. The streams crossed in this portion of the route all drain southward into Norton Bay.

Geology

Mineral Resources

Large known deposits of oil and gas occur north of the Brooks Range. Scattered known outcrops of sub-bituminous and lignite coals occur along the route both north and south of the Brooks Range and near the Koyuk River to the west.

Known areas of high geothermal potential occur in the west central and western sections of the route. A fair number of mineral claims for copper, lead, zinc and gold have been staked along the route on the south flank of the Brooks Range, just north of the route near Kobuk, and north of Haycock.

The total value of hardrock minerals and energy produced from 1880 through 1970 in the area through which this route would pass was in excess of $51,055,500. This figure does not include the large amount of gold dredged from the Hogatza area.

The potential for the discovery of additional energy resources is good to high north of the Brooks Range. Along its western end, the route passes through two large sedimentary basins close to areas of good potential and within whose boundaries additional energy resources can be expected.

The route also passes through several metallogenic provinces beginning on the south flank of the Brooks Range. Foremost in importance is a copper-lead-zinc belt along the south flank of the Brooks Range which the route parallels to the Kobuk area. In the Kobuk area, north of the route, Kennecott Copper Corporation holds two properties, Bornite and Arctic Camp, believed to contain 30 to 35 million tons of high grade copper and lead ores combined. Between Kobuk and Norton Sound, there exists a good potential for the occurrence of gold, tin, platinum, and uranium.

Erosion

Most of the proposed route crosses extensive areas of low outwash deposits of silts sands and gravels. The natural vegetation in the area, although not dense, is sufficiently continuous to inhibit wind erosion.

The northern portion of the route has a somewhat higher stream sediment load during the summer months than does the remaining portion of the route. Sediment loads of streams suggest, however, that stream erosion throughout the area of the route is low in comparison with other streams in the State.

Geologic Hazards

Seismicity--The historic level of seismicity is low along this entire route. Data available from the University of Alaska (Johnson and Hartman, 1969) suggest that in the past 75 years one earthquake with a magnitude of about 7.0 and several smaller earthquakes have occurred along the route.

No data has been gathered on the potential for lateral movements along the route. The potential for an earthquake of magnitude 7.0 to 7.5 should probably be considered across this segment of the route.

Mass Wasting--Mass wasting hazards along the proposed route consist mainly of slides and flows of rock and debris from steep-sided glacial deposits and from glacier-scoured and oversteepened bedrock slopes. Few problems would be anticipated within the generally flat to gently sloping terrain across most of the proposed route. Where the route crosses low divides and parallels streams alluvial and colluvial deposits may cause problems. Solifluction may occur on sloping colluvial surfaces and near streams in alluvial silts if they are ice-rich.

Permafrost--The entire length of the proposed pipeline is underlain by continuous permafrost (Ferrians, 1965). Permafrost is generally present within a few feet of ground surface and is present throughout the area except beneath larger streams and lakes. Permafrost is probably thicker, closer to the ground surface, more widespread, and more ice-rich in finer-grained colluvial and organic-rich alluvial materials than in the sand and gravel areas along the route.

Soils--Soils from Prudhoe Bay south to the junction of this route and 8.2.1 have been described in that section.

Table 8.2.4-1 describes the soils around the lake.

Water Resources

Surface Drainage

The proposed route crosses the northern tributaries of the Koyukuk River, parallels the Kobuk River for a distance and turns south crossing several small streams entering Kotzebue Sound. The route then passes over a divide and crosses several streams entering Norton Sound.

Both the Koyukuk and the Kobuk Rivers have been gaged by the U.S. Geological Survey and data is published in cooperation with the State of Alaska on these streams.

Flooding usually occurs with spring breakup of the streams in late May or early June of each year and periodic summer flooding may occur because of high rainfall during summer months. Flows of streams decline throughout most of the summer reaching near zero flow during the winter months.

The rivers and most streams in lowlands that would be crossed by this route are characterized by a low gradient, a tortuously meandering course, and heavy spring flooding. Flooding during spring is typical and subsidence of the waters frequently continues through much of the early summer. Flooding has a profound effect on vegetation and, therefore, waterfowl use. Rivers are naturally clear (nonglacial) although they carry heavy silt loads at flood stage.

Small streams are numerous, and though some are steep at their headwaters in the uplands, the lower portions meander across the lowlands in a pattern similar to the larger rivers.

There are several types of lakes and ponds: upland basins, ice-formed lakes on the flats, river flooded lowlands, and oxbows. Few lakes exceed 1,000 acres and most are less than 100 acres. Spring runoff, summer thunderstorms, and river flooding charge the lakes; thus, most have variable water depths and shorelines from year to year. Depths seldom exceed 15 feet and usually are much shallower.

Water temperatures in shallow lakes reach 70°F and above in mid-summer, creating ideal conditions for heavy growth of aquatic plants and invertebrates, which serve to indicate a high fertility of different lake basins in this area where chemical analyses have not been made.

Lakes are normally clear although some may be slightly turbid during periods of flood. Most waters are brown from organic stains that leach from surrounding uplands. They are unpolluted or otherwise unchanged by works of man.

Table 8.2.4-1 Soils prospect - Golovnin route

Soil #	Description	Miles	Percent of route	Location
1.	Poorly drained gravelly soil with overlying peat layer	14	3.0	Pick River-Shungnak area
2.	Poorly drained gravelly soil with overlying peat layer in association with well drained brown gravelly soils	27	6.0	Purcell Mt. area, Sheklukshuk Range
3.	Poorly drained loamy with overlying peat layer	178	37.0	Koyuk River area, Buckland River; Kobuk River
4.	Poorly drained loamy soil with overlying peat layer in association with well drained gravelly gray soils	19	4.0	Golovnin Bay; Koyuk River area
5.	Poorly drained loamy soil with overlying peat layer in association with well drained loamy gray soil	10	3.0	Alatna-Helpmejack Hills area
6.	Poorly drained loamy soil with overlying peat layer in association with peat	12	15.0	Lower Koyuk River
7.	Poorly drained loamy soil with overlying peat layer in association with poorly drained gravelly soil	72	15.0	Buckland River; border of Selawik Basin
8.	Poorly drained loamy soil with overlying peat layer in association with well drained thin gravelly soil having a dark acid surface layer	55	12.0	Elim Reserve; Koyuk River area

Table 8.2.4-1 (cont.)

9. Poorly drained gravelly soil in association with well drained gravelly gray soil	45	9.0	Golovnin Bay area; Granite Mountain
10. Well drained brown, gravelly soil in association with poorly drained gravelly soil having an overlying peat layer	6	1.5	Sheklukshuk Mountain Range
11. Well drained thin gravelly soil in association with poorly drained gravelly soil having an overlying peat layer	37	7.5	Selawik Basin
Total	475	98.2	

Ground Water

Circulation of ground water is generally shallow and controlled by structure to the principal river basins where movement is downstream.

Alluvial deposits are the principal aquifers for ground water, which is greatly restricted by permafrost. When under pressure from the frost, ground water bursts to the surface in places, forming conical hills of mud and debris called pingos. The quality of the ground and surface waters along the route has not been studied, but is at present almost totally unaffected by local human uses.

Water Quality

Chemical quality of surface waters is generally good. Dissolved solids content ranges from less than 50 mg/l to nearly 200 mg/l. Major streams have the highest dissolved solids content. All waters in the area are of the calcium bicarbonate type. No objectionable constituents were found.

Very small amounts of data on ground water exist within the area. Generally the ground waters available for quality testing have been from shallow sources at or near streams. This water is of good quality, low in dissolved solids and of a calcium bicarbonate type.

Water Uses

The principal users along this route from Prudhoe Bay to its junction with route 8.2.1 are and will be the Companies engaged in oil and gas exploration, development and transportation. West of the junction of the two routes, individuals and small villages are the only human users of water.

Vegetation

Detailed vegetative information is lacking for this route. The Joint Federal-State Land Use Planning Commission for Alaska prepared a review of ecosystems for their 1973 report. These ecosystems are primarily based on vegetative types and will be used in this section to provide vegetative information. That section of this route from Prudhoe Bay south to its junction with route 8.2.1 has been described in that route description.

Ecosystems (vegetative types)

The ecosystems (vegetative types) crossed by this route and approximate percentages of amount of route covered are tabulated below:

Ecosystems Crossed

Ecosystem	% Traversed
Lowland Spruce - hardwood	22
Low Brush, Muskeg-Bog	1
Wet Tundra	10
Alpine Tundra	2
High Brush	1
Upland Spruce - hardwood	18
Bottom-Land Spruce - poplar	19
Moist Tundra	27

Lowland Spruce-Hardwood--This Ecosystem is a dense to open interior lowland forest of evergreen and deciduous trees, including extensive pure stands of black spruce. Black spruce are slow growing and seldom exceed 8 inches in diameter or 50 feet in height. Cones of this tree open after fire and spread abundant seed, enabling black spruce to quickly invade burned areas. The slow-growing stunted tamarack is associated with black spruce in the wet lowlands. Like black spruce, it is of little commercial value, seldom reaching a diameter of more than a few inches.

Rolling basins and knolls in the lowlands have a varied mixture of white spruce, black spruce, and paper birch, aspen and poplar. Small bogs and muskegs are found in the depressions.

Undergrowth species include willow, dwarf birch, lowbush cranberry, blueberry, Labrador tea, crowberry, bearberry, cottongrass, ferns, horsetail, lichens and a thick cover of sphagnum and other mosses. Large areas burned since 1900 are covered by willow brush and very dense black spruce sapling stands.

Low Brush, Muskeg-Bog--This system is found in two areas: Coastal: Muskeg and bogs are usually found in wet, flat basins. Vegetation is varied, but commonly consists of a thick sphagnum moss mat, sedges, rushes, fruticose lichens, cottongrass, Labrador tea, common juniper, crowberry, willow, cranberry, and blueberry. Shrubs are dominant over the sedge and herbaceous mat in exposed and drier areas. Ponds containing aquatic plants are often present in peaty substrate. Interior: Extensive bogs are found where conditions are too wet for tree growth. Bog vegetation consists of varying amounts of sedges, sphagnum and other mosses, bog rosemary, resin birch, dwarf Arctic birch, Labrador tea, willow, cranberry, and blueberry. Localized saturated flats have large patches of cottongrass tussocks. Areas of tall willow, alder brush, and widely spaced dwarf spruce and tamarack are found within and around the marginal higher portions. Bog surfaces often have uneven, string-like ridges. These surfaces are too wet for shrubs.

Wet Tundra--This system is usually found in areas with little topographical relief. Standing water is almost always present in summer and numerous shallow lakes are common. In northern areas, permafrost is close to the surface, and microrelief features in the forms of polygons and cottongrass, usually forming a mat rather than tussocks. A few woody and herbaceous plants occur on the drier sites above the water table. Rooted aquatic plants occur along shorelines and in shallower lake waters.

Associated plants are lichens, mosses, low-growing willows, dwarf birch, Labrador tea, cinquefoil, beach rye, lowbrush cranberry and occasionally bog cranberry. Characteristic rooted aquatic plants are bur reed, pond weed, pendent grass, and mare's tail.

Alpine Tundra--These systems are found on all mountain ranges of Alaska, and on exposed ridges in the Arctic and southwestern coastal areas. The system consists of barren rocks and rubble interspersed with low plant mats, both herbaceous and shrubby. White mountain-avens are dominant in northern areas and the Alaska Range and may cover entire ridges and slopes along with many low growing herbs, such as moss-campion, black oxytrope, Arctic sandwort, and several lichens, grasses and sedges.

Associated species are resin birch, dwarf Arctic birch, cassiope, crowberry, alpine azalea, Labrador tea, mountain heath, rhododendron, Arctic willow, dwarf blueberry, bog blueberry, and cranberry.

High Brush--These are dense to open deciduous brush systems.

Coastal Alder Thickets--These are extensive Sitka alder thickets often having a well developed grass and fern layer below: Associated species are bluejoint, devilsclub, willow, Sitka mountain ash, currant, thimbleberry, salmonberry, blueberry and huckleberry.

Floodplain Thickets--The subsystem is similar from the rivers of the southern coastal area to the broad-braided rivers north of the Brooks Range. It develops quickly on newly exposed alluvial deposits that are periodically flooded. The dominant shrubs are willows and alders. Associated shrubs are dogwood, prickly rose, raspberry, buffaloberry and high brush cranberry.

Birch-Alder-Willow Thickets--This subsystem is found near timberline in interior Alaska. It consists of resin birch, American green alder, thinleaf alder, and several willow species. Thickets may be extremely dense, or open and interspersed with reindeer lichens, low heath type shrubs, or patches of alpine tundra ecosystems. Other associated species are Sitka alder, bearberry, crowberry, Labrador tea, spirea, blueberry, and mountain cranberry.

Upland Spruce-Hardwood--This ecosystem is a fairly dense interior forest composed of white spruce, birch, aspen and poplar. Black spruce typically grows on north slopes and poorly drained flat areas. Root depths are shallow. Fire scars are common.

White spruce averaging 40 to 80 feet in height and up to 16 inches in diameter occurs in mixed stands on south facing slopes and well drained soils. It forms pure stands near streams. Aspen and birch average 50 feet in height. Poplar averaging 80 feet in height and 24 inches in diameter occurs in scattered stands along streams.

Undergrowth consists of mosses with grasses on drier sites and with brush on moist slopes. Typical plants are willow, alder, ferns, rose, high and low brush cranberry, raspberry, currant and horsetail.

Bottom-Land Spruce-Poplar--This tall, relatively dense interior forest system is primarily white spruce, locally mixed with cottonwood or balsam poplar. In general, the commercial stands of white spruce are on level to nearly level floodplains and low river terraces. On more favorable sites, 100 to 200 year old spruce with diameters to 24 inches and heights to 110 feet are found.

Cottonwood and balsam poplar usually occur with white spruce as a successional system. They are replaced at maturity by white spruce. Both cottonwood and poplar invade floodplains and deglaciated valleys and grow rapidly to heights of 80-100 feet with diameters to 24 inches.

Undergrowth is generally dense, consisting of high and low shrubs including American green alder, thinleaf alder, willow, rose, dogwood, Labrador tea and berry bushes. The forest floor is usually carpeted with ferns, bluejoint, fireweed, horsetails, lichens, herbs and moss.

Portions of floodplains are barren during periods of low water, and some periodically flooded backwater areas contain meadows of tall grass with clumps of willow.

Moist Tundra--These ecosystems usually form a complete ground cover and are extremely productive during the growing season. They vary from almost continuous and uniformly developed cottongrass tussocks with sparse growth of other sedges and dwarf shrubs to stands where tussocks are scarce or lacking and dwarf shrubs are dominant. Associated species are arctagrostis, bluejoint, tufted hairgrass, mosses, alpine azalea, wood rush, mountain-avens, bistort, low-growing willows, dwarf birch, Labrador tea, green alder, Lapland rosebay, blueberry, and mountain cranberry.

Cottongrass-tussock type is the most widespread of all vegetative systems of Arctic Alaska. In the northern area, it is often dissected by polygonal patterns created by underlying ice wedges.

Human Influences on Existing Vegetation

To date, the human influences on vegetation have been very minimal. Except for isolated areas, the vegetation is in its natural state. Fires have affected the vegetation but most of the fires are started by lightning.

Unique, Sensitive and/or Threatened Ecosystems or Communities

This proposed route traverses an entire area which is considered by many as "sensitive." It takes considerably longer for damaged areas to recover than it does in a more temperate environment. Plant growth is slow throughout most of the area.

Wildfires

Although all vegetation ecosystems crossed by the proposed pipeline route are subject to fire, they differ in their ability to carry a fire, once it has begun. This is tabulated below:

Vegetative Type	% by Type	Rate of Spread	Resistance to Control
Upland Spruce & Hardwood	18	High	Medium
Lowland Spruce & Hardwood	22	High	High
Moist tundra	27	Medium	Medium
Bottomland Spruce & Poplar	14	Medium	High
Alpine Tundra	2	High	Low
Wet Tundra	10	Low	Low
High Brush	1	Low	High
Low Brush	1	Medium	High

All of the proposed route passes through lightning prone areas and will be exposed to the effects of large lightning-caused forest fires during the period June through August.

Man-caused fire potential exists mainly during the period of May through September. The exception will be the deep burning winter camp, warming, or other fires that reach peat beds of sufficient mass to sustain fires through winter months. These fires will burn to the surface and ignite surface fuels during the summer months.

Potential for man-caused fires will increase as the route moves from the moist coastal tundra to the lowland spruce and Alpine tundra. This is consistent with fires rate of spread in these fuels.

Adjacent vegetation can be ignited by fires originating in structures such as living quarters, garages, and pump houses. Gas blowouts or petroleum fires that ignite vegetation are equally capable of being an ignition source for wildfire. Other sources include signal fires and those caused by arson.

Wildlife

Information concerning the portion of this route from Prudhoe Bay to its junction with route 8.2.1 has been discussed in the report on that route. This route from that junction west and south is bounded on the south by the proposed Koyukuk National Wildlife Refuge, and on the north by the proposed Selawick National Wildlife Refuge. The Golovnin area itself is included in the proposed Alaska Coastal National Wildlife Refuge. The wildlife information for the route from Prospect to Golovin is abstracted from the Environmental Impact Statements for these proposed refuges and their areas of ecological concern.

Selawick Area

Mammals--Big game and furbearers are important in this area as well as throughout the State because of their economic, subsistence, and recreational values. While the other mammals may not receive similar attention, they are a necessary part of the ecosystem which must function properly if the others are to flourish.

Grizzly bears occur throughout the route, with seasonal concentrations where salmon or berries are abundant. While population data are lacking, the population within the Selawick area is regarded as being moderate to high. Black bears tend to be restricted to the forest lands and the transitional areas between forest and tundra.

Wolves are common within the region and can be found throughout the Selawick and Kobuk drainages. Wolves within this region are dependent upon caribou of the Arctic herd, moose, and sheep.

Wolverines are found throughout the region and within the proposed refuge. Availability of carrion, prey, and berries constitute the major needs of this hardy species which can survive in relatively barren areas. Wolverines are dependent upon either caribou or reindeer for much of their food.

Arctic fox tend to be found in the coastal and treeless habitat, while the red fox and the coyote extend westward to the limits of the forested lands. Lynx are also present in the area.

Moose were scarce in the Selawik area until 50 to 75 years ago. Now they are found throughout the unit, with concentrations on major streams. They are apparently both increasing in number and expanding their range.

Birds--Of 352 species of birds recorded in Alaska more than half have been recorded from within the Kotzebue Sound-Selawik region. Of the 142 species recorded within the region, 109 are nesting migrants, 15 are nesting residents, and 18 probably occur only as nonbreeding migrants and vagrants.

Situated near the crossroads of the Asiatic-North American Flyway, the region includes habitats used by nesting, summering, molting, and migrating birds.

A good proportion of the wetland habitat within the region is important to many species of nesting and migrating waterfowl, shorebirds, and other water-related groups of birds. Geese, brant, and swans congregate in Eschscholtz Bay, Hotham Inlet, and Selawik Lake in fall prior to migration.

The breeding population of about 234,000 ducks within the Selawik-Kobuk-Baldwin Peninsula region averages about 44 ducks per square mile, or only slightly over the densities on the Yukon Delta. This population has produced fall flights of over a half of a million ducks. See Table 8.2.4.-2 for average populations of ducks.

Goose populations are believed to be comparable with those in the better habitats throughout the State. The cackling Canada goose is found throughout the Kotzebue Sound area during summer and fall along with the somewhat larger and more numerous Taverner's Canada goose. Both of these species of small geese are prized game birds along their entire migration route which terminates in Washington, Oregon and California.

White-fronted geese are numerous (probably numbering in the tens of thousands) and widely spread within the area. Black brant and emperor geese breed in the estuarine babitat along the coast.

Pintails are the most abundant dabbling duck species, comprising two-thirds of the dabbles and one-third of all ducks observed during aerial surveys. American widgeon, green-winged teal, mallards, and shovelers comprise the majority of the other dabblers.

Oldsquaws, three species of scoters, and four species of eiders are the most common seaducks nesting in the area.

Densities of yellow-billed loons within this region are perhaps only surpassed by those found on the Seward Peninsula. The arctic and redthroated loons are abundant here as in most coastal lowlands of western and arctic Alaska. The common loon, reaches its northerwestern limits in the region--its habitat being the forested lakes and ponds.

Sandhill cranes, which migrate through the Central and Pacific Flyways to wintering rounds in the southwest United States and Mexico, are found nesting in large number throughout the wetlands along the route.

Gulls, terns, and jaegers are seasonally abundant--primarily from spring through summer. Gyrfalcons are likely to be found nesting in the hills to the south of Selawik Lake in the Waring Mountains and the hills facing Hotham Inlet between the Kobuk and Noatak Rivers.

Rough-legged hawks, golden eagles, and short-eared owls can be found throughout the area. Boreal owls, hawk owls, and goshawks are restricted to the forested areas. Snowy owls appear irregularly at any season of the year in search of lemmings.

The passerines, both in individuals and in species, far outnumber any other group of birds in the area. They range in size from the tiny warblers and redpolls to the raven.

Fish--Information on fish catches within the region is generally based upon estimations and extrapolations of limited data. While estimates are

Table 8.2.4-2 Average populations of breeding ducks, peak populations of breeding ducks and estimated fall populations within the Selawik-Kobuk-Baldwin Peninsula region as calculated from 14 years (1957-1970) of aerial survey data

	Average Population	Peak Population
Mallard	47,000	---
Pintail	67,800	---
Green-winged teal	7,900	---
American widgeon	23,000	---
Shoveler	1,100	---
Subtotal - Dabblers	104,500	
Canvasback	600	---
Scaup (2 species)	83,800	---
Goldeneye (2 species)	300	---
Bufflehead	300	---
Subtotal - Divers	85,000	
Oldsquaw	25,600	---
Eider (4 species)	0	---
Scoter (3 species)	18,600	---
Red-breated merganser	Trace	---
Subtotal - Misc.	44,200	
Total all Ducks	233,700	315,600
Total Ducks per sq. m.*	43.7	59
Projected Fall Flight**	421,000	568,200

* Waterfowl habitat is estimated to include 5,350 square miles in the Kotzebue Sound-Selawik region.

** Ducks in this region are assumed to annually produce 0.8 young per adult in the breeding population.

far from precise, they do show the relative magnitude and importance of certain species in the subsistence economy. The subsistence fisheries within the Northwest Alaska Native Association Regional Corporaton area, for example, harvest an estimated 1.9 million pounds of fish annually. Silver salmon are also commercially harvested in quantity.

Koyukuk Area

Mammals--Moose are common to the area and are found along the stream bottoms. The flooding that occurs along the Yukon and the tributaries that drain the study units promotes heavy stands of willow on the bars and margins of the watercourses. Willow is a major item of winter moose food and sometimes herds of 40 to 50 can be seen feeding in one willow stand. There have been no systematic counts in the area, but they appear to be at least as numerous as on the Yukon Flats where one moose per two square miles was found in 1962. Based on this figure, there are at least 4,000 moose inhabiting the area.

The Beaver Mountains Caribou Herd, estimated at about 3,000 animals, uses this area in winter. Old records indicate this herd was far larger around the turn of the century and was an important element in the survival of the gold miners on the Upper Innoko River.

Black bears are found throughout the area. No studies have been made in the region, but based on densities on the Yukon Flats, there are about 1,000 animals within the area to be crossed by the pipeline.

Grizzly bears of interior Alaska range predominantly on the uplands and treeless areas but are occasionally found on all portions of the lowlands. Grizzlies use the area, but are probably less than half as numerous as black bears.

In recent years nearly 9,000 beaver have been marketed from the area of route influence accounting for 40 percent of the entire Alaska beaver catch.

The number of principal furbearers estimated within the area include muskrat (2 million), mink (20,000), otter (600), marten (2,000), weasel (6,000), wolverine (150), lynx (2,000), red fox (3,600), wolf (200), and coyote (60). Populations of these animals, particularly lynx and muskrat, fluctuate so that in any given year the population might be very different from these estimates.

Porcupines, ground squirrels, snowshoe hares, and red squirrels are well distributed across the region and make their contribution as a food source through the years. Mice and other small mammals are important elements in the food web.

Birds--A few hardy birds remain in these latitudes all winter including the grouse, ptarmigan, raven, jay, grosbeak, crossbill, chickadee, redpoll, and snow bunting.

The Arctic peregrine falcon is the only known endangered wildlife species occurring in this area. Nesting probably does not occur.

Judged by demand, waterfowl are the most valuable resource along the route. The fall flight averages over 800,000 ducks and probably more than 100,000 geese. Numbers of waterfowl fluctuate from year to year. Although not as abundant as some species of ducks, Greater and Lesser Canada and white-fronted geese are perhaps the most important species relative to the size of their continental populations.

Scaup are the most abundant duck in the Koyukuk Valley with a population of about 50,000 while pintails with a population of about 110,000 are most abundant on the Innoko River. Other important species include widgeon, mallard, green-winged teal, goldeneye and scoter, all exceeding populations of 25,000 for the combined Koyukuk and Innoko River regions.

There are about 330 trumpeter swan occurring in the Koyukuk River. This population probably constitutes the northwestern limit in the range of this species. Local residents report that swans are increasing. The remote nesting sites of the trumpeters have been naturally safe from human intrusion most of the summer except where extensive muskrat trapping occurs in late May.

Fish--Anadromous fishes migrate to the ocean when young and ascend freshwater streams as adults to spawn; these include salmon and some sheefish. Of the six species of Pacific salmon, only chum, coho, and chinook ascend the Yukon River as far as the Innoko and Koyukuk Rivers.

Resident fishes remain in fresh water throughout their life, although they may make definite migrations. Resident fishes of the Koyukuk-Innoko drainages include northern pike, arctic grayling, whitefish, cisco, longnose suckers, inconnu (sheefish), burbot, lake chub, trout-perch, and sculpin.

The sheefish or inconnu inhabits many northern lakes and rivers and is found in both the Koyukuk and Innoko Rivers. Within the United States it is found only in Alaska.

The longnose sucker, whitefish, and cisco are common inhabitants of both lakes and streams. They are important forage fish for pike and sheefish. The burbot, also referred to as the ling or lush, reaches a weight of 60 pounds.

Alaska Coastal Area (Bering Sea NWR)

Mammals--Although a variety of terrestrial mammals occurs in the area they are insignificant compared to the variety and number of marine mammals. One or more species of seals, sea lions, walrus, sea otters, and polar bears inhabit the waters of coastal western Alaska. Sixteen species of whales, seven of which are endangered, can be found in the offshore waters. Two species of porpoise and one dolphin are found in the warmer waters of the North Pacific.

Harbor seals are the most widely distributed of the seal species. They may be found resting on beaches or offshore rocks and islets. Ringed, ribbon, and bearded seals, and the Pacific walrus are more commonly associated with pack ice than with land areas, but also occasionally haul out on islands and rocky points.

Polar bears once denned on St. Matthew and Hall Islands but were exterminated by hunters nearly a century ago. At the present time their distribution is largely confined to areas with pack ice.

Land mammals include arctic and red foxes, otters, and mink. Grizzly bears, wolves, wolverines, and caribou are found along the sea coast areas.

Birds--The nesting areas of an estimated four to six million seabirds lie offshore or along the beaches, but data on populations of birds are meager and the number may actually be much larger. The route passes between (within 20 miles of each) the proposed Selawick National Wildlife Refuge and the Koyukuk National Wildlife Refuge.

Distribution of species nesting in dense colonies are best known in the highly visible (seabird "cities" on ledges of marine cliffs), and consequently were favored in selecting the proposed refuge units. Thus, black-legged kittiwakes, common and thick-billed murres, tufted and horned puffins, and several species of cormorants are represented in the area. These species forage throughout the Chukchi and Bering Seas, the Gulf of Alaska, and other areas of the North Pacific Ocean to the Asian Continent.

In addition to seabirds, the cliff habitats are used by other species, particularly Arctic peregrine and gyrfalcon, hawks, and eagles, which find seabirds a ready source of food. Rough-legged hawks and white-tailed sea eagles have been observed near colonies of seabirds along the Bering Sea. To the east across Golovnin Bay near Dickson Bluff the Coastal National Wildlife Refuge is proposed.

Fish--There are small populations of freshwater fish in the coastal area because of general lack of freshwater habitat.

Marine fish and shellfish species in offshore waters are vitally important as food for seabirds and marine mammals. Commercial fisheries and fish processing are of particular economic importance in the Norton Sound area.

Socio-Economic Resources

The Socio-economic resources for the areas which may be crossed by that portion of this route from Prudhoe Bay to its junction with route 8.2.1 has been discussed in the report on that route, This discussion is primarily based on the people living in the area that might be affected by this route. This discussion for the most part was taken from various environmental impact statements on proposed Federal reserve lands selected under provisions of the Alaska Native Claims Settlement Act.

Portions of the land that may be used by this route are utilized by the Native people of several different communities for subsistence activities. The communities of Anaktuvuk Pass, Kobuk, Shungnak, Allakaket, Evansville/Bettles, Koyuk, Huslia and Golovin are the native villages that would be encountered along this route. The inhabitants of these villages depend, for the most part, on the natural resources of the area for their subsistence. Those villages that are served by ground transportation are trending toward a cash based economy but this is not the dominant means of subsistence at this time. The inland Eskimos, or Nunamiut people of Anaktuvuk Pass--situated deep within the Central Brooks Range--rely heavily on the caribou, and other plant and animal resources of the high plain upland plateaus, passes, and river and stream basins. In addition, to the southwest of the proposal area, the inland Eskimo people of Kobuk and Shungnak villages travel up the Kobuk River and its tributaries into areas included in the proposed park. To the south and east, the Indian and Eskimo communities of Allakaket/Alatna, and Evansville/ Bettles, and the old mining community of Wiseman all on the Koyukuk River, occasionally travel into the area for subsistence or recreational purposes. In the near future, a population increase is expected to develop adjacent to the proposed park in connection with the construction of the trans-Alaska oil pipeline.

The social and cultural patterns of each of these groups of Native people are intimately tied to their relationship to the land and its resources. The small and remote inland villages participate only minimally in the cash economy of northern Alaska. The river communities depend on the rivers, not only for the fisheries resources, but for communications with neighboring communities. Anaktuvuk Pass, isolated by location and climate, continues important social and cultural ties with the Arctic coastal communities and the Koyukuk and Kobuk communities to the south. Overland travel in the winter is possible, but modern means of transportation and communication via the airplane is increasingly used for long distance travel to the coast or to the interior.

Changes are occurring in each of the communities as subsistence activites are being modified to accommodate new needs for cash. New technology is increasingly available (in particular the snowmachine) and access to sources of cash income for the Native people are having their impact on the numbers of people involved in subsistence gathering and amounts harvested.

The population of the area is a cross-section of the people of Alaska. The inland Eskimo of Anaktuvuk Pass constitute a distinctive cultural pattern among the northern Eskimo groups. The Nunamiut of Anaktuvuk Pass retain their traditional reliance on the caribou as their principal source of food. The individual and community life also revolves around the caribou. Previously, the people of Anaktuvuk Pass were seasonally nomadic, but are now permanently settled around the school and airstrip facilities. Most are bilingual, speaking English as well as Inupik, although some individuals do not speak English.

Because many Nunamiut moved to the coastal villages of the Arctic Ocean, or to the inland communities of the Noatak drainage in the early 1900's, the Anaktuvuk people have family and social ties beyond the area.

Village leaders are active in the affairs of the Arctic Slope Native Association and Regional Corporation and deal regularly with Federal and State agencies who provide needed services. No alcohol consumption is allowed in the village. Until recently, with the advent of the Alaska Native Claims Settlement Act and the oil pipeline construction, Anaktuvuk's remote location had served to moderate the impact of Western social and economic institutions. Community gatherings feature songs, dancing, and storytelling.

Cash is needed in varying amounts, by most residents within the routes sphere of social and economic influence. Fishing gear, cutboard motors, ammunition, guns, snowmachines, and a variety of household goods currently used in subsistence pursuits, all require moderate amounts of cash to purchase or maintain. Other commodities being purchased in increasing amounts by local residents include food staples, clothing, liquor and tobacco. Sources of cash income within the area are limited. Since few opportunities exist in the region for wage employment, many residents go to Fairbanks, Kotzebue or Barrow or other urban areas for seasonal or full-time jobs. A few jobs do exist in the region in Federal and State government operations, guiding, air taxi services, and arts and crafts. Federal and State governmental functions which provide employment and cash income for the people of the region include administration and operation of the schools, public health service programs, health and welfare programs, postal service, transportation, aviation, weather services and land management services--principally firefighting. Local governments have played a negligible role in providing wage employment. Governmental expenditures that contribute to the cash income of the people of the area include public assistance. In addition to limited unemployment compensation payments and social security benefits, the residents receive three types of income assistance; Bureau of Indain Affairs payments, food stamps, and State welfare payments (which include the categorical programs of Old Age Assistance, Aid to the Blind, Aid to the Disabled, and Aid to Families with dependent children). The material living standard for persons who utilize both subsistence and public assistance has undoubtedly improved. Some people derive cash income from the sale of fur pelts and arts and crafts products. Tourism and service industries are limited in the area. Guiding and air charter services, as well as accommodations and hunting supplies bring a cash income for a few people, principally at Bettles. According to 1972 State records, there are 133 Alaska hunting guides licensed to conduct hunts in the Arctic regions of Alaska, including the proposal area. However, only a few of these are regular users of the area.

Most people must travel out of the area for wage employment. A few residents of Kobuk and Shungnak may go to Kotzebue or Fairbanks for seasonal employment on construction jobs or in the commercial fisheries of the Kotzebue Sound. Some residents of Anaktuvuk Pass may go to Barrow for seasonal employment on construction jobs or in the oil drilling camps. Few people belong to labor unions, but for those who do, union hiring is done out of Fairbanks. Many of the people of the area travel to Fairbanks for seasonal construction jobs, and fire fighting. Some may move to Fairbanks in search of permanent wage employment.

The length of stay varies greatly, and depends on a variety of factors. Many have difficulty adapting to urban life styles, finding jobs and housing. With the commencement of oil pipeline construction activities, an unknown number of local residents will find seasonal and permanent employment on either the construction project or in a supportive industry. Agreements have been made between the pipeline construction company and Native groups which ensure their employment on the project. Peak employment levels are expected to be reached during 1975 and 1976, after which will follow a sharp decline in pipeline related job opportunities.

Many areas along the route have attractions and varied potentials that encompass general recreation, natural environment, primitive areas, Natives and their communities. Various proposals and developments are pending: the Gates of the Arctic National Wilderness park and National Wildlands, Koyukuk National Wildlife Refuge, Kobuk Valley National Monument, Selawik National Wildlife Refuge, Noatak National Ecological Refuge, Cape Krusenstein National Monument, and Chukchi-Imuruk National Wildlands. If they are realized additional numbers of tourists and recreational-type people will be attracted to the area.

The recognition of mineral potential (Seward Peninsula) began with the discovery of placer gold in the late 1800's. Subsequent exploration has revealed the presence of lode gold, tin, lead, zinc, antimony, tungsten, platinum, flourite, and coal. The reactivation of gold mining at Nome, the Lost River tin and flourite initial activities, oil and gas exploratory work, the exploratory copper mining in the Kobuk area are indicative of a possible radical change from prospecting and assessment work of the past to major development and exploitation of the mineral resources in the future.

Land Use

There are no conventional agricultural activities along most of this route. In the Golovnin area there are several reindeer husbandry operations. Reindeer grazing has been carried on in the Seward Peninsula area since the 1915 era. The carrying capacity has been estimated at 24,000 deer with the last reported count being 13,000. An analagous situation occurs over most of the route with subsistence use of the wild caribou herds that winter south of the Brooks Range and summer on the Arctic Slope of Alaska.

The forestry resource is quite limited along most of the route because of severe soil limitations. The existing stands are white and black spruce, which are occasionally used in log cabins. A sawmill has operated sporadically in the Norton Sound area at Elim. There is no forestry management.

The route passes through no industrial lands, per se. It passes nearby the community of Bettles which is a center for air transportation services in the northern interior of Alaska. Most of the route is completely uninhabited.

The route crosses many streams which provide the necessary passage-ways to and from spawning grounds for, at least, two commercial fishery areas in the Kotzebue Sound and Norton Sound areas. There is a small, local commercial fishery in the Golovnin area, where chum salmon are caught, frozen, and shipped out. In the past there has been a limited herring saltery operated in the same area.

The route does not go through any existing mineral extraction or processing areas. Near the village of Kobuk there is a large potential copper deposit. Many of the streams crossed by the route have gravel deposits.

There are no developed transportation facilities and access is only by dogsleds, snowmachines, aircraft, and boats capable of operation in undeveloped areas.

Transportation into the region is mainly by planes; large planes to Galena, Tanana, and Bettles, and bush planes elsewhere. There is barge traffic on the Yukon River. The Koyukuk and Innoko Rivers are both historic transportation routes with some irregular barge traffic, particularly on the Koyukuk.

The closest link with the Alaska Highway System is nearly 200 miles east of Galena at Manley Hot Springs and at the point of junction with the now built Alyeska Oil pipeline haul road.

The Alaska Department of Highways and the U.S. Bureau of Land Management have envisioned the possible need for a system of roadways connecting the villages around the proposal area. One transportation corridor to possibly include both a railroad and highway along the north side of the Yukon follows this route.

The trails used by trappers, prospectors, and aboriginal traders were generally winter trails that utilized the frozen rivers and lakes as much as possible; thus, they were actually more travel routes than improved trails. Trails across many portages have been used for centuries. At present, any major changes in the transportation system seem far in the future.

The route crosses vast expanses of unpopulated land. There are no integrated utility systems along the route. Electricity is supplied through local generators with distribution confined to the immediate vicinity of the village. In most villages water is obtained from a local source such as a river or lake; the villages do not have distribution networks. Many of the villages have radio transmitters. Telephone service may be available in some villages.

The following are existing Federal or State reserves that lie along or in proximity to the route. a. Existing Natural Landmarks--Walker Lake - A very clear and large mountain lake in the Brooks Range, about 250 miles northwest of Fairbanks. Arrigetch Peaks - Very jagged mountain peaks in the Brooks Range, about 250 miles northwest of Fairbanks. b. Proposed--Gates of the Arctic National Park has been proposed by the National Park Service. This pipeline route may pass through the southern extention of the proposal.

Selawik National Wildlife Refuge has been proposed by the U.S. Fish and Wildlife Service. This pipeline route may pass through the southeast corner of the proposal. The route would also pass near the proposed Koyukuk National Wildlife Refuge.

Proposed Ecological Reserves (by Resource Planning Team, JF-SLUPC)

South Fork, Koyukuk River. River bottom and upland black spruce vegetation. About 1,000 to 5,000 acres.

Iniakuk Lake. A fairly large sub-arctic lake, known to contain large fish populations. About 18.5 km².

Kobuk River. A typical, moderate-sized arctic, clear run-off river. The pipeline route may cross the river in the segment proposed for an ecological reserve.

Kobuk. River bottom successional stages in the upper Kobuk River. About 5,000 to 10,000 acres.

At the eastern end of the route, near Bettles, the land ownership is a mixture of Federal withdrawals for the native village of Bettles and land already selected by the village. The route, in its journey westward, travels through two primary land withdrawal types. Both are land withdrawals pursuant to Section 17 of the Alaska Native Claim Settlement Act. The 17(d)(1) lands are withdrawn for further classification and public interest studies. The 17(d)(2) lands are withdrawn for consideration and possible inclusion into one of the four national systems. The route crosses two areas proposed for the Gates of the Arctic National Park and the proposed Selawik National Wildlife Refuge. The route also passes through three areas of land selected by the State of Alaska and through areas selected by the villages of Bettles, Kobuk, Shungnak, Koyuk, Elim and Golovnin, pursuant to Sections 11 and 12 of ANCSA. The classification of the State lands is just now under way and no results are available.

There are various types of settlement claims scattered all along the route. The large majority of these settlement claims are native allotment applications pursuant to the 1906 Native Allotment Act and are concentrated along the streams and lakes in the area of the route.

Disposals from federal ownership would include the lands selected by the State of Alaska and lands that will be patented to the various native corporations as they select them. The third type of disposal may be patented to individuals as individual settlement claims are perfected.

There are no significant less-than-free situations along this route. Near the western terminus of the route there are several reindeer permits. There are no known rights-of-way or other permit situations of any significance.

Paleontological, Archeological and Historical

This route passes through an area with known, significant archeological sites. Numerous sites are located along the Kobuk River, including those in the Onion Portage Archeological District, an entry in the National Register of Historic Places. These sites add important information on man's emergence in North America. The potential for further finds along the Kobuk River is high.

Historic resources along the route include the villages of Bettles, Kobuk, Koyuk, Dime Landing, Haycock, Elim, Moses Point, White Mountain, Golovin and Golovin Mission. Many of these villages served as supply centers for gold mining operations in the late 1800's and early 1900's. The Iditarod Trail (a winter trail from Seward to Nome, blazed in the winter of 1910) approaches the route near Koyuk, and parallels it to its termination at Golovin Bay. Old roadhouses line the Iditarod Trail at about 15 mile intervals.

Insufficient data exist to estimate the paleontological potential along the route.

Recreational and Esthetic Resources

There are no established recreational areas along this gas pipeline route. It is an undeveloped wilderness area with rich recreational potential. It is currently used by hunters, fisherman, skiers, hikers, and other wilderness seekers. Current recreational use is difficult to estimate. However, Department of the Interior planners predict steady increases in visitation to proposed "four-systems" lands in the area of the gas pipeline route.

Gates of the Arctic National Park in the Central Brooks Range is proposed to protect a diverse array of arctic scenes and landscapes varying from the granite spires of the Arrigetch Peaks (whose name in Eskimo means "fingers of the hand outstretched"), to rolling arctic tundra nowhere else represented in the National Park System, to spruce-clad interior lowlands.

Comprising 8.36 million acres, the park contains the complete Arctic Slope watersheds of the caribou-inhabited Killik River and the south slope North Fork of the Koyukuk. The latter lies in the eastern, Mt. Doonerak Unit of the park, which is the portion made famous by the writings of Robert Marshall. The western, Mt. Igikpak Unit, includes a portion of the placid Alatna River, a fine float stream rimmed by colorful layered mountains.

Air Quality

With the exception of the area at the junction of this route with that described in 8.2.1 and the Alyeska oil pipeline route there is little man caused, unnaturally occurring air quality degradation. Wind blown dust from dry areas of glacier till or flower, caribou herds migrating across dry lands and smoke from forest fires are now the main factors of air quality degradation.

Environmental Noise

Again except for the eastern junction of this route with that described in section 8.2.1 there is little unnatural noise along this routes right-of-way. An occasional gun-shot, airplane or boat motor noise may intrude on the silence. Around populated areas, of course, there is more continual noise.

Impact Analysis

All impacts contained in this section are only for that area from the junction of this route and the route described in 8.2.1 to Golovnin.

Summary of the Major Impacts

1) Climatic condition such as severe cold, blowing snow and ice fog could occur along the entire route, this would cause delays in construction and maintenance schedules and at times delays in repair activities.

2) Permafrost, frost heave and slope stability could affect the construction and integrity of the pipeline. The entire route is over continuous permafrost areas and much of this is in ice rich soils which increases the adverse impacts. Permafrost degredation will occur when construction schedules overlap into non-winter months, and during summer maintenance of the operating systems.

3) The formation of aufeis and frost bulbs are icing problems that have a high potential for occurring along this route. These would have adverse effects on manmade facilities such as roads and bridges.

4) The additions of toxins and pollutants and the removal of water related to construction and maintenance of the pipeline would have severe impacts to the ecology of the areas adjacent to the pipeline. These impacts would be very noticeable in that most of the route lies in wilderness areas.

5) Emergency repair operations in summer would have major permanent adverse impacts to the vegetation of the tundra caused by vehicle traffic.

6) Construction and maintenance of the pipeline could affect the thermal regime of the tundra and by so doing severely damage the drainage of the tundra and impair further repair activities.

7) Even low emission levels of sulfur dioxide could have a pronounced effect on lichens, although this should have no major impact on caribou.

8) Socio-economic impacts will be beneficial in that local native corporation revenues would be increased and social and government services would be increased. Adverse impacts would be the demand for housing and the decline in Native culture.

9) The route passes through an area with known significant archeological sites along the Kobuk River. There is potential for damage to these sites but also potential for discovery of new sites.

10) This route would pass near the proposed Kobuk Valley National Monument, Cape Krusenstern National Monument, Chukchi-Imuruk National Reserve, Koyukuk National Wildlife Refuge and the proposed Selawick National Wildlife Range may be transected. The route also would greatly impact the proposed Gates of the Arctic National Park.

Shipping Route - Norton Sound to California

The ice in Norton Sound from October to July leaves only three months of ice free shipping.

These impacts and others are analysed in greater detail in the following analysis.

Detailed Analysis

Climate

This alternative pipeline route would have little effect on the climate of the area.

During the construction phase of the project, however, the operation of mechanical equipment would cause additions of particulates from exhaust and crankcase emissions from diesel and gasoline engines. Impacts would be most severe at and near airfields, maintenance sites, borrow sites, and at points where construction is taking place.

Operation and maintenance phases of the project would have similar impacts, although to a lesser degree and these impacts would be more specific in location, primarily at compressor sites.

Construction of the pipeline would add dust to the atmosphere through construction of permanent access roads and opening of borrow pits, as well as at airfields in summer months.

During operation and maintenance phases of the project, additions will be from borrow pits and permanent access roads. Addition of dust is inevitable with construction and operation of the project.

The impact of added dust and other particulate emissions to the atmosphere could adversely affect vegetation by smothering it, slowing growth, or killing it because of pollutants.

Ice fog is one of the naturally occurring climatic conditions which will be detrimental to use of roads and airfields in the area of the proposed project.

Potential sources of additional water vapor would be equipment exhaust, aircraft, emissions from incinerators, discharge of effluents, and from living quarters during the construction phase of the project.

During the operational and maintenance phases of the project some of these sources will have a lesser effect, but the proposed addition of compressor stations along the pipeline would also provide conditions suitable for the formation of ice fog.

An increase of ice fog would have adverse effects in transportation by reducing visibilities below the minimum required for flying and perhaps driving.

The area extending south from Norton Sound to the Aleutian Chain, borders entirely on the Bering Sea. Meteorological conditions can be classified as maritime in the summer resulting from the presence of large fetches of ice-free waters, and continental in the winter when coastal waters are blanketed with ice masses.

Foul weather is most prevalent throughout the Bering Sea and along its coasts. The sea is frequented by winds, most of which blow at 22 to 44 knots, although higher winds blow periodically. Gale winds, 28 knots and above, are most common in the fall. In late spring and summer, the winds are usually accompanied by fog and rain, which often restricts visibility. Fog occurs in every month of the year along the coast, and blowing snow conditions during the winter reduce the periods of good visibility along the coast. Ice fog is also a frequenent occurrence along the Bering Sea coast, and when combined with light winds may be quite persistent.

Sea ice is characteristic to both the Bering Sea and its coastal areas. The extent and nature of the ice varies considerably and results in generally unpredictable conditions. Ice formation usually begins in October, and by December the ice encompasses the entire region from Norton Sound to the Alaska Peninsula. The ice is constant until the breakup begins in early June, and by late June the ice generally recedes to beyond Point Hope. By July, the ice retreats to the southern boundary of the Bering Strait.

Ice breaking operations would be required to keep ports within the region open during winter months, and much of the area is considered generally hazardous to navigation throughout the year due to combinations of ice floes, sea ice, fog and rough seas.

Topography

Actions associated with the construction of this route such as material, borrow, building, construction, and the mound over the ditch would all have the effect of changing the visual aspects of the area. This change would more adversely affect the aesthetic qualities of a wilderness area than the topography.

Geology

In many cases the proposed pipeline would affect the geologic environment, but in other cases, the geology would affect the pipeline. For example, it is obvious that the pipeline would not affect the seismicity of the area; however, an earthquake-induced landslide could cause the pipeline to rupture, and then, in turn, the fires that might result and the maintenance disturbances during repair could have a significant impact on the geologic environment.

The factors that make this proposed project different from other gas pipeline projects are the extensive areas of permafrost terrain to be crossed, the abundance of ice-rich permafrost along the proposed route, and the transmission of the gas at temperatures below 32°F.

Most of the material to be used in construction probably would be sand and gravel and would be obtained from the active flood plains and terraces along the larger rivers. It would be necessary to know precisely where the borrow sites would be and the types and quantities of material being removed before one could assess the extent and severity of terrain scarring that would occur. Some changes in environment would be caused by the transportation and redistribution of these borrow materials, but probably the most important impact of using the natural construction materials along the proposed pipeline route would be the expenditure of an essentially irreplaceable natural resource. Some of the borrow areas would have to remain open during the lifetime of the pipeline because of an intermittent requirement for material for maintenance purposes.

Mineral Resources--The presence of a gas pipeline with its associated operation, transportation and maintenance facilities would stimulate the exploration for, and development of other oil and gas fields near the pipeline route. Newly developed resources may be moved through parallel pipelines or on highways in this corridor.

If reliable surface transportation routes were developed with this pipeline, exploration for, and exploitation of, the mineral resources would be increased.

This would have the impact of further industrial development in an undeveloped area with all the beneficial and adverse impacts of development.

Erosion and Mass Wasting--Accelerated erosion would be especially difficut to control along certain segments of the proposed pipeline route because fine-grained, ice-rich permafrost soils are extremely sensitive to disturbances by man. During both the construction and maintenance phases, damage to the tundra by construction equipment could occur. In this event, the underlying permafrost would thaw more deeply in summer. In ice-rich permafrost areas, if thawing occurred, ponds, small streams, soil flowage, and erosion from surface runoff water would result.

Significant siltation would occur at river and stream crossings where a trench would be excavated in order to bury the proposed pipeline below the depth of maximum scour. Siltation would also occur where sand and gravel for borrow purposes were excavated from active flood plains or from terraces adjacent to the flood plains. In addition, if accelerated erosion is not controlled along the proposed pipeline right-of-way, silt will be washed into nearby rivers and streams.

Slope instability is an extremely important engineering problem because if downslope movement of materials is deep enough to incorporate a pipeline, rupture of the pipe could result. Shallow downslope movement, such as solifluction, probably would not directly affect a pipeline, but it could result in redirected surface drainage, accelerated erosion, and thawing of permafrost, and consequently, could indirectly affect the integrity of a pipeline.

Thawing of permafrost because of construction and maintenance disturbances could result in slope failure, especially if the slopes are underlain by fine-grained ice-rich soils.

Wherever possible, slopes underlain by ice-rich permafrost soils should be avoided by careful selection of the alinement. Where it is impossible to avoid these areas, every precaution should be taken to minimize disturbing the vegetation mat and the underlying permafrost so as to prevent or restrict the thawing of the permafrost.

Seismicity--The construction and operation of this alternative system should have no effect on the seismicity of the area.

The effects of earthquakes on the pipeline (as discussed in 8.2.1 Impact Analysis), however, could be severe and must be considered in the planning stage in order to avoid disturbance of the system.

Permafrost--One of the most critical factors to be considered is the thawing of permafrost or perennially frozen ground and all of the related effects. The frozen condition of the soils and the behavior of these soils when thawed have important relations to most of the other geologic factors covered in this statement.

Permafrost with little or no ice generally does not cause serious engineering or environmental problems, but permafrost that is ice-rich can cause extremely serious problems if allowed to thaw (Ferrians and other, 1969). Ice-rich fine-grained permafrost soils, when thawed, undergo a change in volume and a loss in strength. The resulting differential settlement and instability of soils could pose major problems.

In addition to the normal difficulties that confront major construction projects in permafrost areas, a buried chilled pipeline poses special problems: (1) heaving caused by freezing of unfrozen water commonly present in fine-grained permafrost soils. Even though the ground temperature is less than freezing, significant quantities of unfrozen water can be present in fine-grained soils. If the ground temperature were lowered by the chilled gas, part of this water would freeze, causing the ground to heave. This problem could be solved by maintaining the gas at near ambient temperature. The gas would be chilled, however, at the compressor stations along the route, and consequently, it would be at a relatively low temperature when it left a station and by the time it reached the next station for chilling, it would be much warmer but still colder than 32°F; (2) heaving and , under certain conditions, erosion and development of icings at the surface caused by freezing of ground water in shallow aquifers; (3) liquefaction, slope instability, differential settlement, and erosion caused by the thawing of ice-rich soils during the interval between the time of burial and the operation of the pipeline; and (4) heaving caused by seasonal freezing of the thawed, frost-susceptible soils in and adjacent to the trench.

Construction and operation of a pipeline along this route could cause permafrost degradation which could cause damage or destruction to parts of the line and/or its ancillary features. Operation of the line could also cause frost heave which would adversely affect the line by differential movements.

Soils

Because of construction actions in building this line, topsoil will be mechanically contaminated with materials from the organic mat and the subsoil during preconstruction stages by tracked vehicles, grading, bank-cutting, excavating, road building, pipeline trenching, backfilling, building material sites, off-road travel and establishment of gravel roads on soils of coastal plains and uplands.

Mixing of these surface and subsurface materials will be largely permanent in nature. It will open the soil to possible thermal degradation erosion and of course will affect eventual surface restoration.

The effect will be most noticeable if this mixing of soil lessens the vegetative recovery of the disturbed area.

Soils would be contaminated with dust, and impacts from dust will generally be minor and local in the case of blowing dust from the project.

Fuel spills have the potential for a range of impacts on the topsoil, in that pollutants would lessen the ability of the soil to grow vegetation. Degree of impact depends upon site conditions, volume and type of liquid and corrective action. Spills of lubricants, and other chemicals will have a similar impact on soils.

The construction of airstrips, roads, support sites, and material stockpiles impact the soil by exposing material to wind erosion during most stages of the operations. Surface and air traffic on roads and strips and grading of these facilities during operation of the pipeline will contribute to wind erosion of soil. Stockpiling of fill or excess materials from excavation of clearing will also provide a source of exposed mineral or organic materials for wind erosion. The wind erosion potential at riverbanks will be increased by the addition of unprotected sandy materials on fill banks.

Impact of this exposure of soil to wind erosion will be to strip some areas of needed top soil, add dust to the air and could reduce vegetative growth.

Off-road all-terrain vehicle use causes surface soil compaction. Scarring and consequent water accumulating in depressed areas lead to serious thermal degradation and eventual erosional cutting as the organic surface mat subsides, exposing the underlying mineral soil. The extent of this adverse impact is largely dependent upon the ice content of the soil and the success of contested theory related to construction of a snow/ice road in snow and water deficient areas.

Unscheduled maintenance and emergencies, such as pipeline rupture requiring summer use of heavy construction equipment, can cause damages that exceed many times over the terrain impacts of the initial construction.

Ice roads if not carefully constructed and maintained will cause soil compaction and/or disturbance of the surface organic layers. This, of course, could lead to serious local erosion and severe negative impacts upon the environment.

Water Resources

The annually recurring problems of the Alaska Department of Highways in combating the effects of icing (aufeis formation) at bridges and on road surfaces are evidence of the difficulties likely to be encountered along any roads built through permafrost terrain in Alaska. The appearance of icings on the slopes of excavations is a frequent phenomenon even where icings have never before formed under natural conditions. Therefore, the engineering activity of man must be considered as one of the basic factors in icing formation.

Sections of this alternative gas pipeline would be routed through areas in which natural icings occur. It also appears likely that some natural icings would become larger and that new icings would form because of construction activities. The possible effects of these icings would be to (a) impair or prevent vehicular traffic on roads downgradient of the ground disturbance, and (b) temporarily divert surface-water flow, causing erosion at unexpected and thus unprotected sites. This would affect the integrity of the pipeline.

The proposed pipeline alinement crosses numerous streams. Because of the special engineering-geologic problems posed in these situations, each stream crossing and flood plain area would require individual study prior to final design in order to select the construction mode and special design measures necessary to minimize adverse environmental effects. In fact, failure to make accurate determinations could result in damage to the pipe and even in rupture of the pipeline.

Once the pipeline system is completed, surface drainage would be affected by the berms, cuts, and other structures associated with the pipeline. Those effects caused by disruption of surface drainage could be significant if proper control measures were not taken, and even with proper measures, these effects could not be completely eliminated.

The erosional effects of flowing water and the freezing and thawing of ice in soil occur naturally along the proposed pipeline route.

Construction of the pipeline and related facilities would cause increases in turbidity and sediment loads of streams through the opening of borrow pits and construction of permanent roads to these locations. Considerable effect of the pipeline construction itself would be felt in the years following construction, but probably would not be reflected until at least the summer season after the first winter construction period.

Large increases in sediment loads would degrade water quality, cause siltation of fish spawning areas, and possibly cause channel changes in downstream areas.

During the operation and maintenance phases of the project, the amount of erosion would increase because of the reduction in soil resistance to stream velocities and destruction of the binding and insulating effect of vegetation along the route. The amount of possible erosion cannot be predicted because: 1) the project description does not give details; 2) the probability and extent of future flooding, icings, and ice-jams are unknown; 3) the erosion effects of floods are difficult to evaluate; and 4) the success of erosion control methods is uncertain.

The problems which would arise from increased sediment and turbidity in streams is a specific site phenomena, although such additions may extend downstream for a long distance. Addition of sediment through construction and operation of the pipeline is an unavoidable consequence, although most additions to sediment and turbidity will probably occur during flood stages on streams when sediment loads are normally high.

The frost bulb effect of the chilled pipe will limit internal drainage in sandy and gravelly soils of the coastal plain by creating a permafrost barrier and cause surfacing of internal drainage waters with the potential to erode unprotected surface in the immediate vicinity of the pipeline. This could add to erosional effects and cause damage to the pipeline and surrounding area.

Very little data are available on ground-water occurrences and movement in the area of this pipeline. In most of the area that would be crossed by the route, the presence of permafrost near the surface generally limits movement of ground-water to the active layer. Ground-water movement at great depths beneath the permafrost should not be significantly affected either by the construction or by the operation of the pipeline. Ground-water movement is important under the beds of the rivers of the area, however, and the pipeline's effect on the movement of this water could be significant.

The presence of a chilled gas pipeline in the bed of a river that has ground-water movement throughout the winter could form a frozen core that could effectively dam the water, forcing it to the surface, and thereby creating river icings (aufeis) where none had existed before. The icing would change the regime of the river, and consequently, could cause bank erosion and scouring at places where the pipeline would not be designed to accommodate these effects.

In areas away from the rivers, the operation of the proposed chilled gas pipeline would reduce the thickness of the active layer above the axis of the pipeline. This raised "permafrost table" would act as a barrier to subsurface groundwater flow across the axis of the pipeline and would either direct the flow parallel to the pipeline or cause the water to surface.

Water withdrawal is very small at present from streams in the area, and will be low during the construction period with respect to the amount of water available throughout the year. Care will have to be observed in large withdrawals during winter because of the effect on downstream fish spawning beds.

Return of camp effluent to the streams could cause additions to the ice fog problems along the pipeline routes during both the construction and operational phases of the project.

The diversion of small drainage systems through the construction of the pipeline would be evident during the years following construction. The effects of this diversion would be changes in the normal drainage channels of the smaller streams, and the additions of several tiny streams into one larger stream could cause erosion, melting of permafrost, and consequent settlement of the ground near the pipeline.

The effects of diversion of local watersheds would be specific in location and have a local detrimental effect. Alterations of the small drainage system would be an unavoidable effect of pipeline construction.

If monitoring and mitigating measures are not taken following construction, the diversions of local watersheds could have a major adverse impact upon the pipeline integrity.

The chemical characteristics of stream water in the proposed pipeline route area are generally believed to be good.

During the construction phases of the pipeline, addition of camp wastes and the potential addition of fuel and oils from spillage would decrease the water quality in downstream areas.

Although a certain amount of spillage and discharge of such materials to the streams is generally unavoidable, the impact would be reduced if all camp wastes were treated and safety precautions, with respect to spillage and dumping of untreated wastes into surface waters, were taken.

Vegetation

The proposed project will destroy vegetation along the pipeline ditch right-of-way and additional vegetation will be destroyed or covered up by gravel in the construction of permanent roads, airfields, communication towers, compressor station camps and related facilities.

Vegetation will be partially destroyed and/or changed by the temporary snow and ice roads along the route used in linking the various borrow areas, stockpiles, coastal installations and related facilities.

Without a natural or artificial cover, degradation of ice-rich soil during the summer could be major and even thwart all early attempts at revegetation until the soils are fully stabilized. The primary method of revegetation is seeding and fertilization.

One of the main impacts of vegetation disturbance will be changes in the thermal regime of the soil. This vegetation disturbance will result from the construction and use of permanent and winter roads and trails and from emergency maintenance during the summer months.

Loss of the plant cover changes the surface albedo and increases the thermal input into the soil, which increases the active layer. If there is little or no ice in the permafrost layer, there will be little surface subsidence and erosion. Natural revegetation will occur rapidly and the surface will be quickly stabilized.

If there is considerable ice in the permafrost, there will be subsidence, thermokarst and thermal erosion. Active movement and erosion may prevent revegetation for several years. Eventually the area will stabilize and natural vegetation will again cover the surface and the active layer will once again decrease in thickness.

The vegetation destroyed by covering up with gravel, as mentioned, is permanently lost. Secondary impacts will be loss of habitat to wildlife and perhaps an aesthetically and visually displeasing change in the vegetation along the route.

The greatest potential vegetative damage may result from emergency maintenance actions in the summer. Heavy equipment will have to be moved across the tundra. The tundra would be compacted, torn up, or possibly receive severe localized damage. The degree of damage, of course, will be directly related to the equipment used, distances traversed in roadless areas, and the frequency of emergency maintenance required. Experience in the Arctic tundra region and studies show that impacts could be of major permanent nature.

The impacts of low ground pressure vehicles on various types of vegetation have been studied in detail by the Arctic Institute of North America. Their report, "The Alaskan Arctic Coast," prepared for the Corps of Engineers, indicates little probable significant damage will occur on the route due to winter use. Summer use poses the most significant potential damage to vegetation.

Surface drainage will be changed with the establishment of permanent roads and facilities. As water concentrates or moves along new paths, vegetational changes will occur. Soil will be removed from the roots killing plants, thaw depth will increase, and dryer land plant communities will drown and/or go through a successional change to aquatic plant communities. Impacts of this nature will be mostly minor--however, permanent and irreversible.

Recent fire history cannot be used to indicate the probability of times when fires will occur due to the area having neither an existing natural or man-caused fire problem. The introduction of men and equipment into the project area will increase the potential of wildfire resulting from activities related to the construction, operation and maintenance.

The potential for man-caused fires is highest during the months of July and August and also increases as activities move from the west coastal tundra to interior brush and forest zones.

The potential ignition sources for man-caused wildfires are as follows: (1) Equipment-exhaust and ignition systems of both vehicles and portable equipment. Vehicular and aircraft accidents. (2) Recreation -- warming and cooking fires from fishing, hunting, and sightseeing parties. (3) Smoking -- discarded smoking material by all categories of land users.

(4) Industrial -- heat sources present during construction and maintenance-operation stages of the pipeline and associated structures, such as welding and cutting torches and debris burning. (5) Structural, gas, and petroleum fires -- adjacent vegetation can be ignited by fires originating in structures such as living quarters, garages, and pump houses. Gas blowouts or petroleum fires can also ignite vegetation. (6) Miscellaneous -- including but not limited to such fires caused by signal flares or fires by arson.

It is likely that the number of fires will increase due to the project, but amount and severity cannot be determined at this time.

Wildlife

Mammals--

Caribou--Caribou are not a major wildlife species along this alternative route. Some animals from the Arctic and Beaver herds may winter in the area and the primary adverse effect would be on their winter foods.

Habitat (vegetative) destruction will be caused by removal of borrow and the covering of the vegetative mat by the roads and permanent facilities will cause the physical breakdown of plant species. Fuel, lubricants, and other pollutants will be spilled on the ground and will kill additional and unknown amounts of vegetation. Construction of permanent roads, stockpiles, communication and compressor sites, will also alter caribou habitat making it unfit for use.

Lichens, the primary winter food of caribou, derive virtually all of their nourishment, including water and minerals, directly from the atmosphere. Atmospheric pollutants therefore are more readily incorporated into the living tissue of lichens than into vascular plants.

Schofield and Hamilton (1970) have pointed out that relatively low emission levels of sulfur dioxide, such as occur at well drilling sites or gas-driven pumping stations, could have a pronounced effect on lichens under the atmospheric conditions that prevail in winter on the North Slope.

This may alter caribou habitat but because of the low numbers of caribou using the area for winter range can be rated as a minor impact. The destruction of vegetation by project construction that is used by caribou for spring, summer and fall grazing will probably have little impact on the overall well being of the herd.

Grizzly Bear, Wolf, Fox and Wolverine--Construction activities relative to this alternative pipeline would cause little direct destruction of grizzly bear habitat. Den sites are vulnerable as are areas along river bottom where these animals tend to feed.

Grading, ditching or borrow operations may occasionally disturb bears in their wintering dens. There are no published data about such an event, however, a bear disturbed from winter sleep in the Arctic probably would not find enough food and eventually starve. It seems improbable that it could dig another den in the frozen soil, and there is only one record of a snow den (Lentfer et. al., 1972). In case of a maternity den or even female with older cubs, the young would almost certainly perish.

The adverse impacts of the proposed project on wolf habitats would be destruction or avoidance by the wolves of preferred denning sites. The project could cause major reduction of wolf food species.

Wolves utilize a variety of places for their dens, but in tundra areas they usually den in hillsides, eskers, or other well drained sites having soil suitable for digging. These sites are also favored by pipeline builders because of drainage features.

Grizzly bear, wolverine, wolves, and foxes are vulnerable to excessive hunting and denning site destruction, and will be attracted by exposed edible refuse or strong food odors. Under the latter circumstance some will be killed in the guise of camp protection. Bears and wolves are vulnerable to harassment by aircraft. A decline of the grizzly bear populations seems to be an inevitable consequence of the construction of the pipeline. This arises from the human attitude toward such powerful predators as well as the value of the hide on the illicit market. It appears inevitable also that there will be a decline of wolverine for the same reasons.

Carnivores, particularly bear, and to a lesser extent, wolverines, wolves, and fox often create nuisances or destroy property and as a result threaten their own well-being. Improper disposal of garbage attracts carnivores which tend to become dependent on the artificial food source and they lose some of their fear of man. Bears, under such conditions, may be a threat to people working or living in the area and may damage buildings and other property, thus necessitating their removal.

Bears, wolves, wolverines and foxes are inclined to investigate and often chew foreign materials. Plastics are particularly attractive. Bears and wolverines also often damage, by clawing or biting, thin metal sheeting, such as aluminum roofing or siding to gain entrance to buildings or for no apparent reasons. Because of these characteristics - carnivores would be involved in damage to service buildings at valve and communications sites and pump stations. This damage, if localized, could require the elimination of the offending animals, and, if extensive, could result in a significant reduction of carnivores along the pipeline route.

The grizzly bear and wolverine are relatively incompatible with human settlement and would be adversely affected by the increased presence of humans in areas adjacent to the pipeline and haul road. Increased protection through regulations and enforcement would only provide a modicum of security for the species, and densities, which are normally low, could be expected to undergo pronounced reduction.

Species occurring in low densities, such as bears and wolverine and wolf, and those with restricted distribution, such as mountian sheep, and moose would be most detrimentally affected by aircraft harassment because their uniqueness increases the likelihood that individual animals would be repeatedly hazed in attempts at photography and close observation. This type of harassment may be reduced through establishment and enforcement of regulations, but experience on Alaska's North Slope suggests that it will continue to be an important source of wildlife disturbance.

Moose--Moose are usually scattered, with winter range being the critical factor in survival. Moose are almost exclusively confined to willow stands in the major river valleys during the winter. It can be anticipated that a proportion of the moose in the river valley along the route would be displaced from the habitat which occurs there. Following construction, several years would be required before the habitat were again fully recovered. Pollutants, clearing of river bottom areas and any other action that destroys the riparian vegetation will reduce these critical moose habitats.

Some moose may be killed by moving equipment striking them during the course of construction activities. Others may be lost by falling into the open trench or becoming wounded and therefore more susceptible to predators in contacts with construction equipment, human activity and etc.

Harassment of moose during the summer could cause them to move from preferred feeding areas.

Small Mammals and Fur Bearers--Small mammals, shrew, wolves, ground squirrels, and mice would have portions of their habitat physically destroyed by the roads, camps, ditches and other facets of the proposed pipeline. This will have a serious effect directly on those animals in the path of construction. Considering the large amount of habitat available to these species, however, the total impact will be minor.

Fuel oil and other pollutant spills at proposed permanent facility sites, along transportation routes and during construction of the pipeline could cause larger areas of habitat damage than the physical removal of habitats by the facilities.

Chronic low key pollution associated with operation and maintenance activities can reduce populations of these small mammals by coating their fur, thus reducing the heat retaining feature and exposing the animal to cold and damp which will kill them.

An unknown number of weasels, coyote, mink, river otter, red squirrel, snow shoe hare and beaver occur in the area of project influence.

The project will adversely affect these species habitats primarily by removing food and/or cover from use. Because of the few numbers of animals involved and the small amount of habitat destroyed the impacts would be minor.

Birds--This alternative pipeline has the potential for some unavoidable, and a large number of avoidable, effects on bird populations through disturbance by aircraft, construction activities, human presence pollution, and direct mortality.

Various forms of disturbance are the major source of potential impact on bird populations along the proposed pipeline routes during construction and operation of the project and its related facilities.

Some species may accommodate to new and increased disturbance, whereas the detrimental effects of increased disturbance could be cumulative on other more sensitive species, such as nesting swans or raptors. Disturbance could increase stress and alter normal behavior patterns during critical life history phases such as spring migration, nesting, molting, or fall migration staging; decrease reproductive success; or cause the birds to desert traditional areas such as molting areas or nesting sites for which there may be no alternative. The impact of disturbance on a particular species is a function of the type and intensity of the disturbance, the time of year, the location, the mobility of the disturbance source, the distribution pattern of the bird, and the species' sensitivity to disturbance. The major sources of disturbances associated with construction and operation of the proposed pipeline are aircraft traffic, construction activities and human presence, permanent facilities, and water traffic.

The effect of this alternative on passerine species would tend to be of a more localized nature, except for oil and other petroleum-based products.

The occupation of passerine habitats by the pipeline-related facilties and the pipeline itself will remove that area from use.

Pollutants spilled out on the ground or into streams will have a wide-ranging effect and could reduce population of song birds in large areas.

The open water along the shoreline, out-falls, or islands in the Alaskan rivers is critical for the nesting, feeding, and mating activities of many bird species. Any destruction or alteration of this habitat could adversely affect populations. Uncontained and unrecovered fuel spills onto the ice or during spring breakup could gather in this open water, render shoreline, island, and sandbar habitat unusable, and pose a direct threat to the birds present.

One aspect of spilled and pooled oil affects birds specifically; it concerns the attraction of birds to pools on the ground, snow or ice. Oil sumps are known to take a toll of ducks, shorebirds, songbirds, and even raptors (King, 1953; Bloch, 1964). Waters that are polluted with oil may be the first to become ice-free in the spring, because of the "black body effect," and attract early migrants. Birds may also mistake oil on ice and snow for open water.

Sea ducks using the Alaskan coast may be particularly susceptible to nesting disturbance, molting disturbance, destruction of nesting or molting habitat, human intrusions, alterations of estuary water regimes, and pollution.

Colonial nesters such as common eider, are known to suffer unusually high egg mortality as a result of disturbance or human intrusion during nesting.

Fish--The effect of proposed pipeline construction on all fish species will primarily take the form of habitat destruction through siltation, reduction of oxygen levels, increased water velocities causing scour of spawning areas, interference with fish movement, and spills of toxic substances into watercourses.

Severe local impact during the construction phase may be expected in areas where extensive construction activity takes place within a small watershed and where riverbanks are insufficiently protected at the site of pipeline river crossings.

Aufeis formation caused by ice roads, winter construction practices, and the cold pipeline can cause serious repercussions on summer fish habitats by reducing water temperatures which could cause late spawning, by physically restricting the movement of young-adult fish, and by removing spawning areas from use.

Many chemicals toxic to fish will be used in procedures associated with the proposed gas pipeline. Although none will be routinely introduced into watercourses, accidental spills will likely result in fish fills and habitat degradation in the vicinity of the spills and possibly in downstream areas.

Erosion is a natural occurring process and all streams carry some level of silt load but any activity that causes additional erosion and siltation can affect streams in a variety of ways. These include: (1) a reduction in light penetration (McKee and Wolf, 1963); (2) a reduction of total productivity (Cordone and Kelley, 1961); (3) a reduction of benthic organisms (Smith, 1940); (4) mortality of fish eggs and embryos (Peters, 1965); and (5) interference with the feeding of and occasionally even the smothering of mussels (Ellis, 1936). Construction of any kind almost inevitably results in some erosion, and even small amounts of mineral matter cause changes in the fauna. (Hynes, 1970).

In areas where culverting is necessary, special attention will be required to avoid both long- and short-term impacts. Culverts associated with permanent roads along the route can, if improperly designed, create barriers to fish. There are an unknown number of culverts associated with the route. Care must be taken, however, in culvert placement especially in small streams because of the adverse effects on grayling populations that can be caused.

Problems associated with proposed project construction during the ice-free period would come from pollutants, poor culvert placement and siltation.

The effect of sport fishing on fish population should be minor. The State of Alaska has prohibited pipeline personnel working on the trans-Alaska oil pipeline from fishing in amy waters five miles or less from either side of the line. It is assumed the same type of prohibition will apply to the proposed gas pipeline.

Socio-Economic

Basic information concerning the socio-economic resources that may be used by this alternative pipeline route have not been defined in sufficient detail to permit anything but a broad-brush analysis.

In an attempt to gauge the impact of this gas pipeline, one must first consider the impact of the Alyeska oil pipeline project, because the base period against which the gas pipeline impact must be measured is not the Alaska of 1974, but Alaska as it is likely to be at the start of this route. It is clear that Alaska will have changed dramatically in response to the Alyeska project. While construction of the Alyeska oil pipeline does not precede the initiation of the gas line, the gas project with its attendant shipping and LNG terminals will be a larger project. No information is available concerning the numbers of workers or length of project work.

Thus, the consideration of socio-economic impacts should be two-phased; first, the anticipated effect of the Alyeska project upon the existing social and economic structure, both on the state as a whole and on the interior region in which the gas pipeline will be constructed; second, the likely impact of the gas pipeline construction project within the context of an Alyeska-impacted state.

In addition to the infusion of hundreds of industrial workers and support personnel requiring an extensive logistical effort -- certain economic benefits will develop as a consequence of the proposed project. The existing transportation, communications, and industrial support infrastructure will experience a higher level of activity over a longer period than that necessary to support the Alyeska oil pipeline effort. The proposed project will stimulate the search for additional oil and gas sources on the North Slope and in off-shore areas. The impact of the project will primarily be felt in transportation, communication, and supply centers, such as Fairbanks and Anchorage. Small towns, especially Golovin, will lose much if not all of their "bush" characteristics.

The primary impact on the communities will result from the increased demand for public services and facilities. Competition for the goods and services by the construction company will tend to be inflationary, making the goods and services scarcer and higher priced.

Employment levels on the proposed natural gas pipeline will equal or exceed those of the Alyeska oil pipeline effort, and will continue to impact adversely on governmental services--principally health, education and safety--and on the cost of living in Alaska.

The development of this pipeline would have some direct and some indirect employment opportunities for Alaskan Natives. The degree of Native employment would depend on numerous factors, many of which are unknown at this time. However, Natives who have worked on construction jobs on the Alyeska oil pipeline will probably transfer to the gas pipeline.

One of the main factors that will work against the employment of Natives on the gas pipeline is the number of non-Natives that will be available for employment. Even before the construction of the Alyeska oil pipeline, Alaska had the highest unemployment rate in the United States. Because of the in-migration of persons to Alaska, the unemployment rate has increased, for example, to 13.7% during the first third of 1974 compared with the 12.3% level for the same period in 1973.

Due to the variables of remote location and probable on-site services for the persons filling industrial jobs, estimates of probable disposable income to be spent within the state can only be speculated at this time. Persons filling jobs resulting from secondary employment, while likely to earn a lower income, will spend a substantially greater percentage of gross income within the state as they will be primarily in supporting communities and not supplied with room, board and other necessities by employers.

Construction of the proposed gas pipeline will have a multi-faceted impact on the socioeconomic environment of the State of Alaska in general and the northern impact region in particular. It will produce jobs, generate State and local revenues, and further stimulate the Alaskan economy. It will attract some in-migrants to the state, increasing the population over what it would otherwise have been. This, in turn, may be translated into a demand for social services, schools, housing, health care, and public safety.

Most of the secondary and indirect jobs will be located in the major population centers-- Anchorage, Fairbanks, and, to a lesser extent, Juneau--and thus these cities, already the dominant communities in the state, will continue to grow at a rate faster than that of the the state as a whole. Also, workers with pipeline jobs who bring families to Alaska are likely to locate their families in the major cities, seeing them on rotation.

Operation and maintenance activities of the proposed gas pipeline will have a direct stimulus impact on the state and regional economy. In addition, the existence of an operating gas pipeline will stimulate the exploration for additional natural gas reserves in Alaska in general and along the pipeline route in particular. This indirect impact, in turn, is expected to produce additional employment in the impact region and elsewhere in Alaska. When new oil and gas reserves are discovered, the resulting expansion of the Alaskan and interior region economies will be of further national and international importance.

A quantitative comparison of economic impacts of the several LNG route variations is possible through an econometric model of the State of Alaska developed by the University of Alaska. A wellhead gas price of $.50 and a production rate of 3.5 Bcf/d produces a wellhead value of $638.8 million, royalties of $79.8 million and a production tax of $25.6 million. For the Golovin route variation, construction employment reaches 7,343 in 1980, including pipeline, marine terminal and liquifaction plant construction; capital investment is $2.7 billion, yielding a property tax of $54.8 million, adding $447.2 million (1958 dollars) to real gross state product, $238 million (1967 dollars) to real wages and salaries, and $163.4 million to state revenues. By the time these construction impacts work throughout the economy of the state, their ultimate impact in 1980 includes an addition to employment of 25,700, population 36,000, personal income $683 million and per capita personal income $630 (Scott, 1975).

In summary construction of this pipeline would sustain and increase the impacts upon Alaska that the Alyeska Oil Pipeline has started.

State, local and Native Corporations revenues will be increased, demands for housing, social and government services increased and some small villages will be forever changed.

Land Use

The only forestry situation that could be impacted would be the sporadic use of white spruce in the area for long cabin construction. Utilization of the timber removed from the construction right-of-way would supply considerable volumes for this purpose. There are no forest management situations presently in the area to be impacted. The land occupied by the pipe itself and other facilities would be removed from forest production areas.

The agriculture in the area is limited to reindeer husbandry in the immediate area of the construction, plus those areas frequented by overland vehicles or aircraft. Destruction of habitat does not appear to be a particularly significant impact. The disturbance of reindeer herds provides a parallel to the disturbance of the wild caribou which are found throughout the region. This route traverses south of the winter range for the Arctic herd. However, wintertime construction could disturb portions of the herd that are present.

The route passes through no industrial land per se. It does pass nearby the Bettles airfield, which is a center for air transportation services in the northern interior region. It is expected that a construction project through this area would significantly increase the traffic for the Bettles field.

The route does, near its western terminus, go just south of another oil and gas province. The availability of a gasoline transmission system would influence the development of that oil and gas province. Should the gasoline be constructed to Norton Sound, it is likely that the gas found in the Selawik Basin would also be transported to Norton Sound for shipping. Once an area is established as an industrial corridor, it becomes a preferred route for future transportation facilities. It is likely that the development of this area as a transportation corridor would influence the location of a transportation facility for oil found in the Kotzebue, Selawik Area.

There are two types of impacts that would occur on the commercial fishery.

The first type of impact is the competition for labor. If an LNG plant were located in the Golvin area a portion of the 600 people required to run such a plant could come from the nearby communities of the Elim, Golovnin, White Mountain, Shatulik and Koyuk. If the local population were hired to construct and operate the pipeline and LNG facility it would detract from the available labor force that is presently utilizing the commercial fishery.

The second type of impact is on the tributary streams which flow into the commercial fishery area. Impacts on these streams would be alteration of water quality, physical barriers, increased access to these streams, and therefore increased fishing pressure by sports fishermen and commercial fishermen.

The residential areas within the route area are all small native villages. These native villages are surrounded by thousands of square miles of open space. It is unlikely that a pipeline will be constructed through any of the residential areas along the route. A secondary impact would be the demand for housing within these areas. These small villages would have very limited if any resources with which to react to the housing demand. Assuming provision of housing by the construction work force, the residual or operational housing demad would be of greater significance to the individual villages. The secondary and tertiary impacts of increased population are really the impacts than would be imposed on these villages. Examples of such impacts would be increased need for health services and social services.

This route does not pass through any existing mineral extraction areas. There are three potential mineral extraction areas that could be impacted. The first would be the gravel deposits in stream courses all along the route. A second mineral area would be the copper deposits near Kobuk. This is a large, valuable deposit. Increased access because of the pipeline could influence the economics of the development of the copper deposit. The third type of mineral extraction area would be the oil and gas provinces which are thought to be located in Kotzebue and Norton Sound areas. The development of a gas transportation system would influence the development of these areas. If shipping facilities and an LNG plant were developed in the Norton Sound area, it is likely that it would influence the transportation of any oil and gas reserves found in the future in these areas.

This alternative pipeline route would pass near several areas proposed for inclusion in either the National Park, Refuge or Wild River System. Increased access to the area would increase interest in these areas and if they are established would influence management decision making processes.

Because of the lack of status of these lands and the uncertainty of the use of this route any further impact analysis would be purely speculative at this time.

Archeological and Historical Resources

Little has been done to gather archeological or historical information along the route. The likelihood of discovering unknown sites along the route, however, is high. Consequently, the likelihood of destruction of unknown archeological sites is high. Salvage operations along the route will contribute to knowledge of Alaskan archeology, but such operations may take place under less than optimum investigative conditions. Sites not on the route will receive minimal impact from pipeline construction.

Recreational and Esthetic Resources

Recreational areas along this route have not been established. However, recreational use of this area of Alaska has increased in recent years. Recreational hunting, fishing, camping, boating, sightseeing, and nature study, are becoming increasingly popular. Establishment of the four-systems proposals in the area will increase recreational use substantially.

If pipeline construction is carried out over this route it might facilitate development of the State's proposed transportation corridor which also follows this route and recreational use of the area would be significantly increased. Whether or not a highway is built along the route, access will increase if the pipeline is constructed.

The pipeline, if constructed, would pass near the proposed Kobuk Valley National Monument, Cape Krusenstern National Monument, Chukchi-Imuruk National Reserve and the Koyukuk National Wildlife Refuge. The proposed Selawik National Wildlife Range may be transected by the pipeline.

With the exception of the proposed Gates of the Arctic National Park and the Selawik National Wildlife Refuge, impacts on the above-mentioned recreation areas would be minimal.

If values for which the Selawik National Wildlife Refuge are comprised, impacts of pipeline construction would be significant.

Construction of the pipeline through the proposed Gates of the Arctic National Park would have a significant impact on the wilderness quality and visual integrity of the park. The State of Alaska has proposed a highway which would generally follow the same route. If pipeline construction facilitates highway construction, impacts caused by newly developed access would be significant.

The development of an LNG plant, a marine terminal and related facilities at Golovin will have a significant impact on the visual integrity of this traditional rural area. The 500-1,000 families required to operate and maintain the facility would contribute significantly to recreational demand in the area.

Increased access and increased awareness of the area because of pipeline construction could also increase recreational use of the area.

Recreational use along the route could be expected to soar if this option is selected. Immediate increases would result from use by construction personnel. If the construction road is opened to the public (or if an independent paralleling system is installed), an area which has received little use would be suddenly visited by recreationalists. Recreational quality would be degraded from expanded visitation to the areas along the route, and by localized impairment of the scenic values.

Pipeline construction here would have significant impact on the visual integrity and natural quality of the landscape. Sport hunting and sport fishing could increase significantly. Trophy species may be reduced. Pipeline construction itself could reduce wildlife potentials, and thereby severely reduce recreational potential. It can be expected that this project in addition to the State's planned highway over the same route and the Department of the Interior proposals will stimulate interest in this area and increase recreational use.

Air Quality and Environmental Noise

There would be both short term, (construction period), and long term (operation and maintenance), degradation of the present air quality and degree of noise along this route. Until a number of items have been identified, such as, location and size of borrow pits compressor and maintenance areas roads and the LNG plant among others, a detailed analysis of this degradation cannot be made at this time. It will, however, equal or exceed that given in the report of route 8.2.1.

8.2.5 Variation: Oxnard-Quigley Station-Hinkley-Eastern United States Description of Project

This variation to the alternative routes would locate the LNG Terminal and regasification plant 4 miles south of Oxnard near Point Magu. Terminal and regasification facilities would be the same as described in section 8.2.1, Description of the Project. This variation is based on Dames and Moore, 1974.

It is assumed that the peak daily rate capacity of the plant would be the same as the Point Conception alternative site (3 billion cuft/day) and that one half of the daily volume would be delivered to customers west of the Rocky Mountains. The remaining half (1.5 billion cuft/day) would be transported to the Eastern United States.

The pipeline system (two 42" parallel pipelines) would be routed through the Ventura basin generally northward for approximately 12 miles to the La Vista metering station. Southern California Gas has two lines (18" and 22" Diam.) that transverse this station. The two lines run from Los Angeles to Ventura. A 34-inch line that is routed from Castaic Junction for Pacific Lighting Service is metered at this location. Modifications to these pipelines to allow reverse flow would eliminate the need for one of the 42" pipelines beyond this point. Exchange agreements and displacement of gas in existing pipelines would deliver Alaskan gas to Northern and Southern California from routed gas at Castaic Junction and Quigley Canyon Station. A 30" pipeline that terminates at Quigley Station from the Arizona Border could be utilized by reverse flow modification and compression to provide Alaskan gas to Arizona.

The other 42" pipeline would proceed north paralleling Southern California Gas Company's existing 34" gas pipeline No. 324. The route would lie along the southern slope of South Mountain, crossing Balcom Canyon and Fox Canyon. Continuing northeasterly across the south slope of Oak Ridge Mountain, the route would ascend to the summit of Oak Ridge, then descend to Tapo Canyon; from Tapo Canyon the route would proceed easterly up the north slope of the Santa Susana Mountains, through Salt Canyon and Patrero Canyon, then descend into the Santa Clarita Valley to the Saugus Junction valve station. From the Saugus Junction station the route would parallel Southern California Gas Company's 34" line No. 225, crossing the South fork of the Santa Clara River and proceeding along the foothills of the San Gabriel Mountains. Proceeding east, the route would cross Oro Fina Canyon and the 150 ft. deep Los Angeles aqueduct before joining Quigley Canyon Station on the north slope of Quigley Canyon. Total distance from the LNG Terminal at Oxnard to Quigley Canyon Station would be 53 miles. From Quigley Canyon Station the route would parallel the right-of-way of an existing 30" pipeline belonging to Pacific Lighting Service. The route would proceed for 78 miles east through Mint Canyon, Aqua Hauser Canyon, over Sierra Pelona and into the Palmdale area, continuing east to a point just south of Adelanto. At this point it would leave the 30" pipeline right-of-way and would take a northerly course along the Mojave River Drainage for 26 miles. The route would closely parallel an existing 18" Pacific Gas and Electric pipeline to Hinkley. At Hinkley the pipeline would join PG&E's two large east-west transmission lines that are described for the transportation of gas from Arvin to the California-Arizona Border in the pipeline - LNG tanker alternative. From Hinkley the gas would take the same routes as described in the pipeline - LNG tanker alternative for distribution to the Eastern United States.

The twin 42" parallel pipeline system would extend 12 miles from the Oxnard regasification plant to the La Vista Station. One 42" pipeline would transport the remaining gas through Quigley Station and on to Hinkley.

New construction for this variation would consist of approximately 12 miles of twin 42 inch pipeline, 145 miles of single 42" pipeline, modification of three compressor stations, and an undetermined amount of modification to existing pipelines.

This new construction would be in addition to the new-construction requirements for the Prime Alternative: Point Conception to the Eastern United States, as listed below:

11 compressor stations
24 pipe and other modifications to existing compressor stations
418.5 miles of 42" OD pipeline
9.5 miles of 30" OD pipeline
13.0 miles of 24"OD pipeline
109.7 miles of 20" OD pipeline
1.1 miles of 16" OD pipeline

Description of the Environment

Climate

The climate in the coastal region of the Santa Clara River Basin (Oxnard Plain) is dominated by the influence of the Pacific Ocean and the semi-permanent North Pacific high pressure cell. The oceanic heat sink is responsible for the moderate air temperatures observed, the mean temperature being in the sixties with a variation which rarely exceeds 80° or falls below 50°F. The stability of the atmosphere in the Oxnard area can be directly related to data available from weather stations at Santa Monica and Santa Barbara. These stations report annual frequencies of temperature inversions of 33 and 41 percent respectively. Such inversions are typically based at an altitude of 1000 to 2000 feet, and are stronger and more persistent during the summer months.

During the summer months, there are periods of morning and afternoon stratus clouds which form at the base of the temperature inversion. These overcast mornings and evenings are usually short-lived because terrestrial heating breaks up the clouds. Sunny afternoons are common.

Such advection stratus are uncommon during the winter months when occasional Pacific storms bring about 10 inches of rain per year to the area. Heavy rains are extremely rare in this part of the state. The winds are generally westerly in direction except when an occasional Pacific storm passes through the area bringing winds from the southwest. Wind speeds are generally light to moderate with afternoon westerly breezes often becoming brisk.

The pipeline route passes through the upper Santa Clara River Basin where several weather systems interact to influence the climate of that locale. These systems include: (1) coastal influences which are characterized by cool temperatures, high humidities, and moderately strong winds; (2) desert influences from the Lancaster-Palmdale area, characterized by high temperatures, low humidities, and moderate to strong winds; and (3) San Fernando Valley influences which are also characterized by high temperatures, but with moderate humidities and moderate winds.

The pipeline terminus at Hinkley is in the Mojave River drainage and this section of pipeline passes from mountain to desert climate after leaving the Sierra Pelona area near Palmdale.

During the summer the area is influenced by hot, dry air of continental origin. During the cooler season of the year, the air over the area is either cool and dry (of continental origin) or cool and moist (of marine origin), accompanied by cloudy skies and widespread light precipitation. The air is hot in the summer and comparatively mild during the winter. Daily ranges of temperature of 30° to 40°F occur in all seasons of the year, especially accompanying dry air. Variations in temperature because of elevation are also great.

Precipitation along the last 60 miles of pipeline route is light, averaging from 4 to 9 in. per year. Heavier amounts, ranging up to 40 in. annually, occur in the mountains near the start of the route. Most of the precipitation falls in the cooler season of the year. Occasionally there are heavy showers during the summer; they usually occur in the mountains and may be accompanied by local flooding.

Relative humidity is generally low throughout the year, averaging less than 50 percent in the midmorning and frequently falling to less than 10 percent during summer afternoons. Dense fogs are almost unknown in the area.

Thunderstorms, accompanied by locally strong winds, may occur during the summer but are generally confined to the mountains. Major hail damage is also rare.

During the winter, strong, turbulent winds may occur. Gusty winds of 30 to 50 knots sometimes accompany frontal systems passing through the area. Occasionally, localized downslope winds may reach speeds of 40 to 50 knots. Local duststorms sometimes accompany strong winds.

Topography

The initial 15 miles of the project lies within the Oxnard Plain in the southern Santa Clara River floodplain, rising from a 20 ft. elevation to 500 ft.

The corridor enters the southern foothills cf South Mountain at MP 15, crossing large sections of vacant undeveloped land to Balcom Canyon. Rising rapidly to the ridge line of Oak Ridge at an elevation of 2300 ft. the route remains on the ridge for approximately 3 miles then descends into Tapo Canyon. Leaving Tapo Canyon, the route traverses Salt Canyon and Potrero Canyon at approximately 1800 ft. elevation. Approximately 4 miles of the route will traverse the Santa Clarita Valley. The route parallels the South fork of the Santa Clara River, enters the foothills of the San Gabriel Mountains and rises for two miles where, at 1600 ft. elevation, it passes through Quigley Canyon Station.

From Quigley Canyon Station, the pipeline route proceeds generally east through Mint Canyon into the Sierra Pelona Valley. Paralleling Aqua Hauser Canyon, the route crosses through the pass between Mount McDill and Sierra Pelona (approx. elevation 5100), and descends into Anaverde Valley to elevation 2900 ft. The route continues easterly between Palmdale and Lake Palmdale then takes a due east course for 37 miles through the relatively flat slopes of Antelope Valley and the Mojave Desert. At Adelanto, the route then turns northeasterly for 26 miles, paralleling the Mojave River drainage to Hinkley (approx. elevation 2600).

Geology

In this section, the local and regional terrestrial geologic setting of the site area is described.

Physiographic Setting

The site is located on the Oxnard Plain of the Ventura Basin within the Transverse Ranges Province of Southern California. The Transverse Ranges Province is a geologically complex, east-west trending geomorphic unit cutting across the general north-west trend of Southern California. The province consists of east-west trending hills and mountains separated by narrow to moderately broad valleys. (see figure 8.2.5-1)

The Ventura Basin is a folded and faulted synclinorium bounded on the north by the Santa Ynez and Topatopa Mountains and on the south by the Santa Monica Mountains. It contains several intra-basin chains of hills and mountains. Two of these chains--Oak Ridge and Camarillo Hills--slope to the west into the flat, alluviated Oxnard Plain, the most extensive lowland in the Ventura Basin. The plain slopes southwesterly at 12 to 15 feet per mile toward the Pacific Ocean.

The highest elevations in the Ventura Basin are about 2,500 feet in the mountains to the north and east of Oxnard. The site elevation ranges from 5 to 10 feet above sea level.

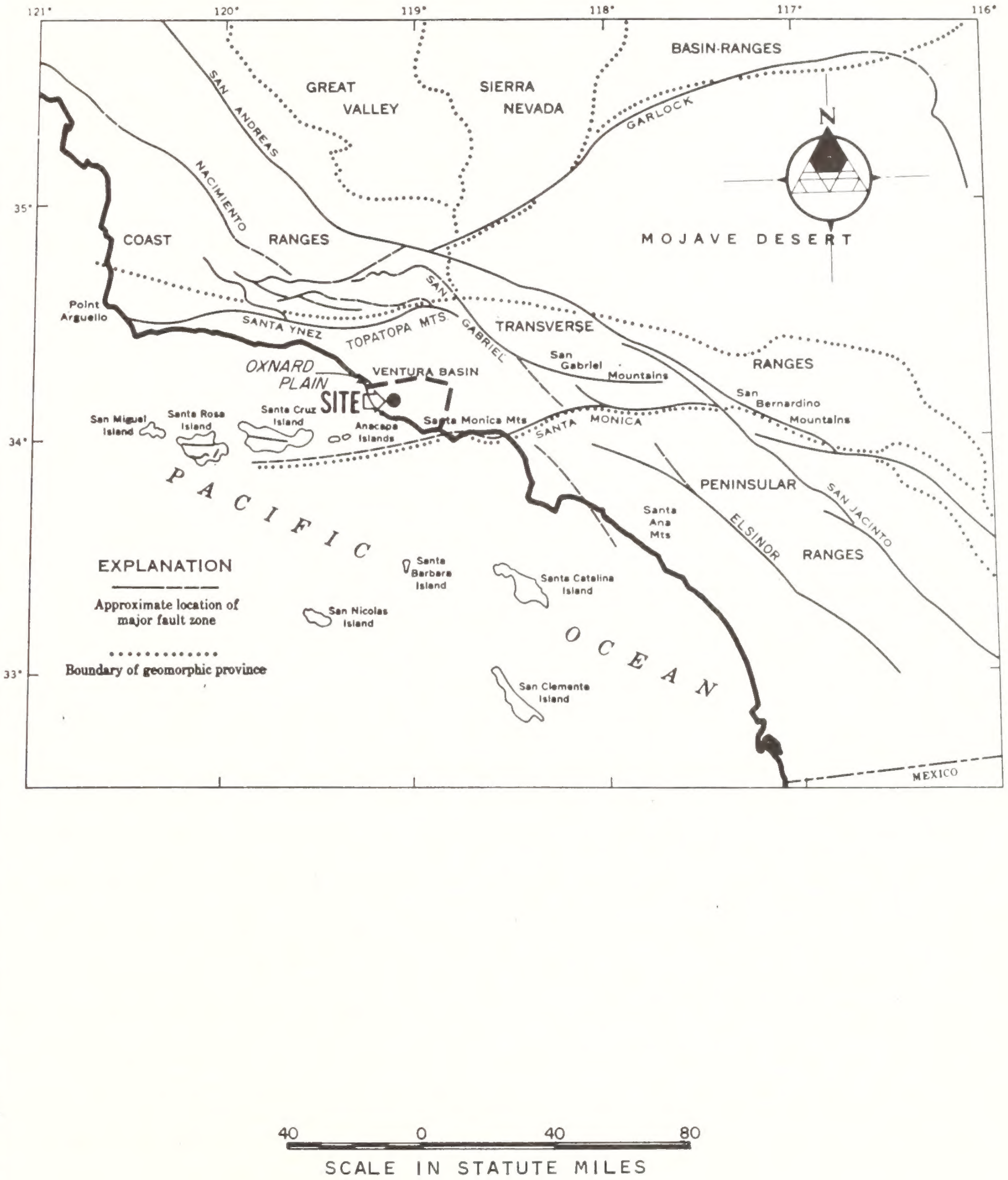
Stratigraphy--The Ventura Basin is an east-west trending structure that has been downwarped during the past 60 to 75 million years. Cretaceous, Tertiary, and Quaternary sediments, with locally interbedded volcanic rocks, have accumulated to thicknesses in excess of 6,000 feet on a pre-Cretaceous basement of igneous and metamorphic rocks. The sediments are dominantly marine and were deformed and uplifted during a period of crustal instability in the mid-Pleistocene epoch.

The Oxnard Plain represents the ancient delta of the Santa Clara River, formed at the end of the last glacial epoch when the Santa Clara was part of a much more extensive river system. Nonmarine sediments consisting of sand, silt, and clay were deposited on the deformed rocks of lower Pleistocene and older ages.

Structure--Structural features in the region resulted primarily from mid-Pleistocene crustal instability. During this deformation, the sediments that had been accumulated in the slowly subsiding Ventura Basin were uplifted, folded, and faulted along east-west trends in response to north-to-south compression. This folding and faulting has continued, with lessened intensity, to the present. The Red Mountain, San Cayetano, Oak Ridge, Simi-Santa Rosa, and other fault zones resulted from this mid-Pleistocene tectonism.

The folding at the north end of the cross section lessens in intensity to the south, where the proposed site is located. The beds underlying the site area are fairly flat-lying to a depth of approximately 2,000 feet.

Faults in Region of the Site--No faults are reported beneath the site or its immediate vicinity. Active or potentially active faults in the Ventura County area include the San Cayetano, McGrath, Oak Ridge, Camarillo



Source: Dames and Moore, 1975, Vol. II

Figure 8.2.5-1 Physiographic setting of the site

Hills, Sycamore, Red Mountain, Simi-Santa Rosa, and Malibu faults. The seismicity of the proposed site area is discussed in the following section.

Seismicity--

Earthquake History--California is located within the circum-Pacific earthquake zone, which is the most seismically active of all zones in the 48 contiguous states. All of California experiences earthquake activity to some degree. In recent years the site area has experienced several seismic events per year, although most were quite small and detected only by instruments.

The major earthquakes that have occurred in Southern California during the years 1912 to 1974 are listed in Table 8.2.5-1.

The general region has a large amount of activity, but, by comparison, activity in the coastal Oxnard Plain is not intensive. There are 4 major concentrations of epicenters: (1) to the southeast in the Los Angeles Long Beach area; (2) to the east in the northern San Fernando Valley; (3) to the north in Kern County; and (4) to the west in the Santa Barbara Channel.

Ninety-one earthquakes reportedly have been felt near the site since 1769. Eighteen of these were Intensity VI or greater, including at least 3 of Intensity VIII. Even the highest intensities felt in this region in the past would cause only slight damage to modern structures.

Recurrence intervals can be developed from the historical data. A recurrence interval gives an indication of how many times per century an earthquake of a certain intensity might occur. This is merely a statistical calculation derived from historical probabilities. The following intervals have been calculated with this in mind:

Intensity	Occurrences Per Century
VIII	2.2
VII	4.0
VI	6.7

Intensities have been held to be related to ground accelerations. Use of such accelerations for design purposes has been reasonably successful in the past when applied to ordinary construction of moderate size. For large construction, and for special units such as tanks, expected ground motions must be considered in detail by the design earthquake method. Because a correlation between intensity and acceleration is difficult, different researchers have developed different values. However, for general purposes Intensity VIII ground motion can be assigned a maximum horizontal acceleration of 0.30g and Intensity VII, 0.10g. Recurrence intervals for the accelerations would be the same as for their corresponding intensities.

In addition to the use of these basic historical data, maximum ground motion was assessed by study of the effects of the largest credible earthquakes generated on various nearby faults and by a computer probabilistic approach. Both of these methods confirmed 0.30g horizontal acceleration as a conservative design basis.

The proposed gas transmission route passes through the Transverse Range and Mojave Provinces of Southern California. The Transverse Range Province is an elongated, geomorphic, and structural unit that trends east-west. The Mojave Province is a gently eastward sloping plain, essentially flat, but

Table 8.2.5-1 Earthquakes of southern California - 1912-1974, magnitudes 6.0 and greater

DATE	TIME (PST)	LAT.	LONG.	MAG.	INT.	FELT AREA +	LOCATION
1915 Jun 22	19:59	32.8	115.5	6.25	VIII	50,000-100,000	Imperial Valley
1915 Jun 22	20:56	32.8	115.5	6.25	VIII	50,000-100,000	Imperial Valley
1915 Nov 20	16:14	32	115	7.1	VII	120,000	Colorado Delta
1916 Oct 22	18:44	34.9	118.9	6	VII	25,000-50,000	Tejon Pass
1918 Apr 21	14:32	33.7	117	6.8	IX	130,000	San Jacinto
1923 Jul 22	23:30	34	117.2	6.25	VII	70,000	San Bernardino
1925 Jun 29	06:42	34.3	119.8	6.3	VIII-IX	--	Santa Barbara
1927 Sep 17	18:07	37.5	118.7	6	VII	75,000	Bishop
1933 Mar 10	17:54	33.6	118.0	6.3	IX	100,000	Long Beach
1934 Dec 30	05:52	32.2	115.5	6.5	IX	60,000	Colorado Delta
1934 Dec 31	10:45	32	114.7	7.1*	X	80,000	Colorado Delta
1935 Feb 24	--	32.0	115.2	6.0	--	--	Colorado Delta
1937 Mar 25	08:49	33.5	116.6	6.0	VII	30,000	Terwilliger Valley
1940 May 18	20:36	32.7	115.5	7.1*	X	60,000+	Imperial Valley
1940 Dec 8	--	31.7	115.1	6.0	--	--	Colorado Delta
1941 Jun 30	23:51	34.4	119.6	6.0	VIII	20,000	Santa Barbara
1942 Oct 21	08:22	33.0	116.0	6.5	VII	35,000	Borrego Valley
1946 Mar 15	05:49	35.7	118.1	6.3	VIII	65,000	Walker Pass
1947 Apr 10	07:58	35.0	116.6	6.2*	VII	75,000	Manix
1948 Dec 4	15:43	39.9	116.4	6.5	VII	65,000	Desert Hot Springs
1952 Jul 21	03:52	35.0	119.0	7.7*	XI	160,000	Kern County
1952 Jul 22	23:53	35.0	118.8	6.4	VII	--	Kern County
1952 Jul 23	05:17	35.2	118.8	6.1	VII	--	Kern County
1952 Jul 28	23:03	35.4	118.9	6.1	VII	--	Kern County
1954 Mar 19	01:54	33.3	116.2	6.2	VI	40,000	Santa Rosa Mountains
1954 Oct 24	--	31.5	116.0	6.0	--	--	Agua Blanca
1954 Nov 12	04:26	31.5	116	6.3	V+	--	Agua Blanca
1956 Feb 9	06:32	31.8	115.9	6.8	VI+	30,000+	San Miguel
1956 Feb 9	--	31.7	115.9	6.1	--	--	San Miguel
1956 Feb 14	10:33	31.5	115.9	6.3	V+	--	San Miguel
1956 Feb 14	17:20	31.5	115.9	6.4	V+	--	San Miguel
1966 Aug 7	09:36	31.8	114.5	6.3	VI	--	Gulf, California
1968 Apr 8	18:29	33.1	116.1	6.5*	--	--	Borrego Mountains
1971 Feb 9	06:01	34.4	118.4	6.6*	XI	80,000	San Fernando

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*Surface faulting

+ **FELT AREA IN SQUARE MILES**

Source: Dames and Moore, 1975, Vol. II

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1956 Feb 14	10:33	31.5	115.9	6.3	V+	--	San Miguel
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1971 Feb 9	06:01	34.4	118.4	6.6*	XI	80,000	San Fernando

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*Surface faulting

+ FELT AREA IN SQUARE MILES

Source: Dames and Moore, 1975, Vol. II

containing occasional short mountain ranges rising only a few thousand feet above the surface of the surrounding plain.

Structure--The Ventura Basin, a subunit of the Transverse Range Province, is a highly folded synclinal structure, containing 1500 to 2000 feet of Cenozoic and Recent sediments. It is traversed by several anticlinal chains of hills and mountains. Faulting in the basin consists of a complex series of east-west trending, south dipping, reverse and thrust faults resulting from predominantly north-south compression during the Late Tertiary and Quaternary periods. Deformation appears to be more intense in the central and northern part of the basin. The San Gabriel Fault, a right lateral, strike-slip fault, trends northwest along the eastern margin of the basin. (see figure 8.2.5-2)

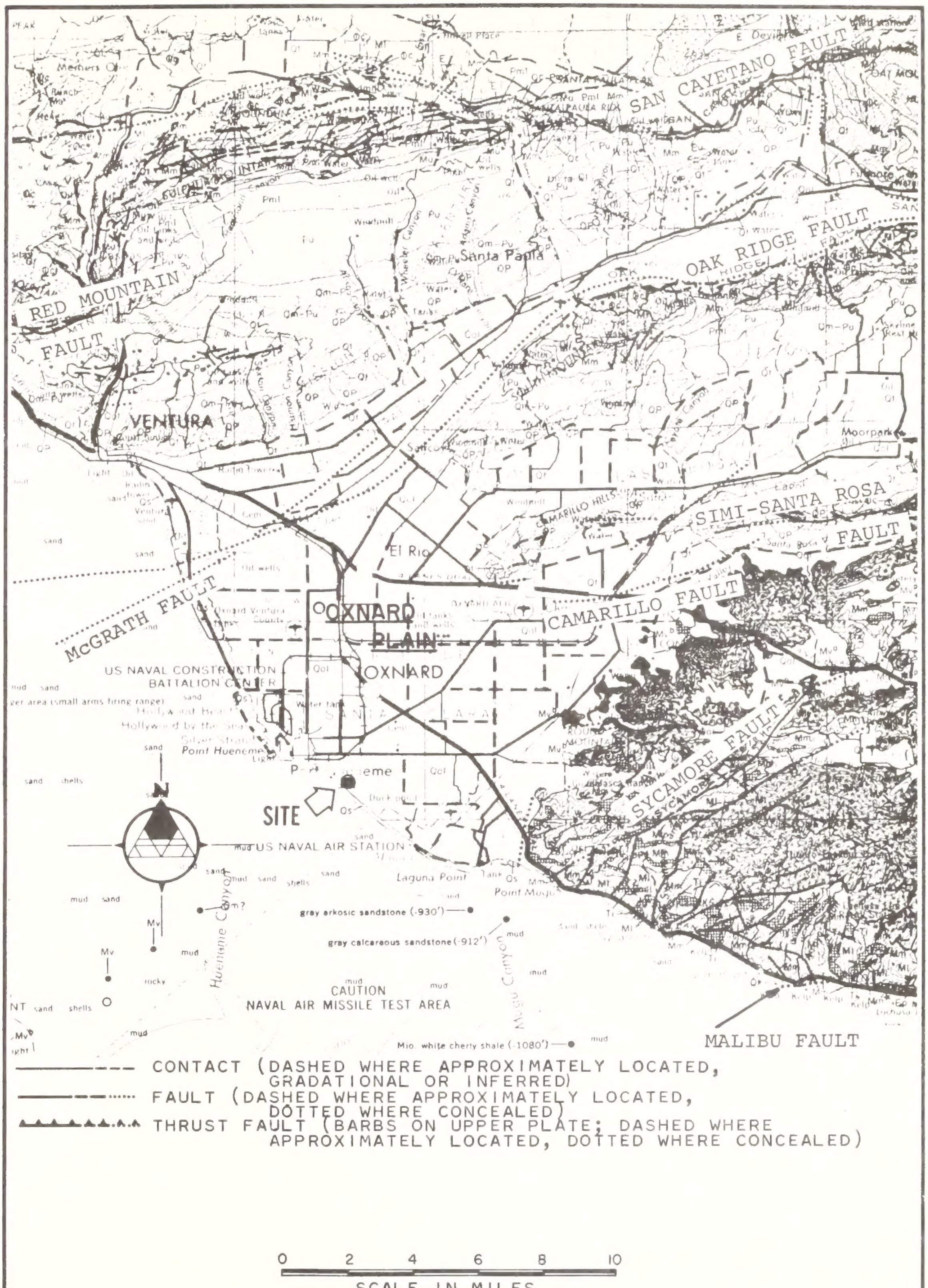
Stratigraphy--The basin consists of a thick sequence of Tertiary and Quaternary sediments overlying Cretaceous sediments and a pre-Cretaceous basement complex of igneous and metamorphic rocks. Bedrock units which are traversed by the proposed pipeline route include (oldest to youngest): Topanga Formation, Monterey-Modelo Formation, Towsley Formation, Pico Formation, Santa Barbara Formation, Saugus Formation, and the San Pedro Formation. Overlying the bedrock units is a variable mantle of loosely consolidated Late Pleistocene and Recent sediments consisting of deltaic, terrace, floodplain, stream channel, slope wash, and alluvial fan deposits. The more recent surficial deposits may attain thicknesses in excess of 150 feet.

The principal water-bearing units in the basin include the Grimes Canyon Aquifer of the Santa Barbara and Saugus Formations, the Fox Canyon Aquifer of the San Pedro Formation, and Late Pleistocene and Recent surficial deposits.

Faults Significant to the Alignment--Several known faults are traversed by the alignment. Most of these are related to the Santa Susana Fault Zone which exhibits surface offsets in Potrero Canyon. The Santa Susana is a thrust fault, approximately 30 miles long, exhibiting as much as 3800 feet of dip-slip and 2000 feet of left lateral separation. Surface ruptures occurred on the Santa Susana Fault Zone during the 1971 San Fernando Earthquake; however, there was no evidence of subsurface movement in the Aliso Canyon oil field where many wells penetrate the fault. The California Division of Mines and Geology (1973a) indicates that the Santa Susana Fault has offset Quaternary deposits. The Santa Susana Fault Zone should be considered potentially active.

The alignment parallels the Holser Fault for about 2.5 miles as it follows Magic Mountain Parkway east of Interstate 5. The Holser Fault is approximately 300 feet to the northeast of the route and is concealed by Recent fan and alluvial deposits. It is a northwest-southwest trending, folded reverse fault dipping steeply to the south. It is about 30 miles long, and is known to have offset Quaternary deposits. It should be considered potentially active.

The alignment crosses traces of the Salt Creek Fault near MP 44. The Salt Creek is a reverse fault dipping steeply toward the northeast. The fault appears to possess some right lateral displacement, having offset conglomerates of the Pico Formation. The Salt Creek Fault is considered as nonactive.


SAN CAYETANO FAULT
RED MOUNTAIN FAULT
OAK RIDGE FAULT
SIMI-SANTA ROSA FAULT
CAMARILLO FAULT
McGRATH FAULT
SYCAMORE FAULT
MALIBU FAULT
VENTURA
Santa Paula
Moorpark
El Rio
OXNARD PLAIN
OXNARD
US NAVAL CONSTRUCTION BATTALION CENTER
Point Hueneme
Port Hueneme
SITE
N
US NAVAL AIR STATION
Laguna Point
Point Mugu
Hueneme Canyon
Mugu Canyon
gray arkosic sandstone (-930')
gray calcareous sandstone (-912')
Mio. white cherty shale (-1080')
CAUTION
NAVAL AIR MISSILE TEST AREA
CONTACT (DASHED WHERE APPROXIMATELY LOCATED, GRADATIONAL OR INFERRED)
FAULT (DASHED WHERE APPROXIMATELY LOCATED, DOTTED WHERE CONCEALED)
THRUST FAULT (BARBS ON UPPER PLATE; DASHED WHERE APPROXIMATELY LOCATED, DOTTED WHERE CONCEALED)
0
2
4
6
8
10
SCALE IN MILES

Source: Dames and Moore, 1975, Vol. II

Figure 8.2.5-2 Active and potentially active faults in the Ventura county area

Other faults which are near the route of the proposed pipeline or whose activity may affect the alignment include the Oak Ridge Fault, San Gabriel Fault and the San Andreas Fault.

The Oak Ridge Fault is located 8 miles north of the route. The Oak Ridge Fault is an east-west trending fault which dips about 70° to the south. The San Gabriel Fault is an 85-mile-long, right lateral strike slip fault. Both the Oak Ridge and the San Gabriel Faults exhibit Quaternary displacement. Although no recent or historical movement has been noted, these faults should be considered potentially active.

The San Andreas Fault is traversed by the pipeline route from Quigley Canyon Station to Palmdale. The San Andreas is a right lateral strike slip fault with several hundred miles of offset.

Other notable faults which should be considered potentially active in the general region of the proposed gas transmission route include: the San Cayetano, McGrath, Oakridge, Red Mountain, Camarillo Hills, Simi-Santa Rosa, Malibu-Coast, and Sycamore Faults. (see figure 8.2.5-3)

Seismicity--The southern California area is one of the more seismically active regions in the United States, lying on the Circum-Pacific Belt. Southern California has experienced over 20 earthquakes of Richter Magnitude 6.0 or greater since 1932. (figure 8.2.5-4)

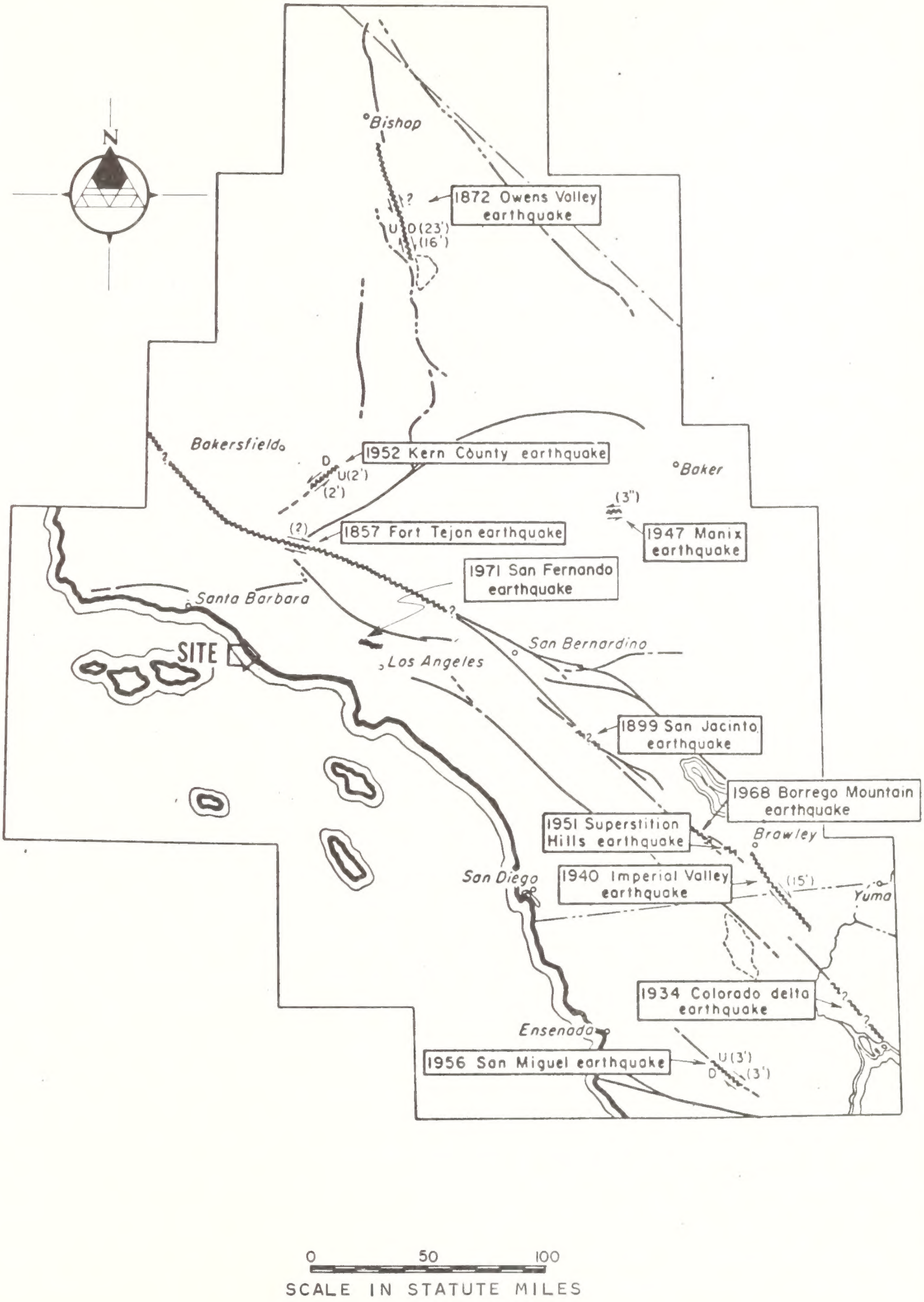
There is at present no geologic or seismologic evidence which would indicate an appreciable increase or decrease in earthquake activity in southern California over the next several hundred years. On the contrary, the geologic processes which have caused earthquakes in the past may be expected to continue to operate and cause further earthquake activity.

1. Mojave Desert Region. The Mojave Desert region is a wedge-shaped structural block which is bounded on the north by the Garlock fault, on the south by the Transverse Ranges, and on the east by a variable boundary defined approximately by the Colorado River. The western half of the block, which would be traversed by the proposed pipeline route, is characterized by a gently sloping plain with numerous isolated hills rising above it. The plain is underlain by pre-Cenozoic crystalline basement rock which is either exposed at the surface or overlain by various amounts of late Cenozoic sediments. The crystalline basement consists of sedimentary, metamorphic, and intrusive igneous rocks. The isolated hills consist of older granitic and younger volcanic rocks. Due to the arid climate and internal drainage, playas develop on the plain.

Precambrian rocks are exposed in the Mojave Desert area and reveal a complex history of deposition in a deep marine basin, followed by uplift and deformation accompanied by severe regional metamorphism.

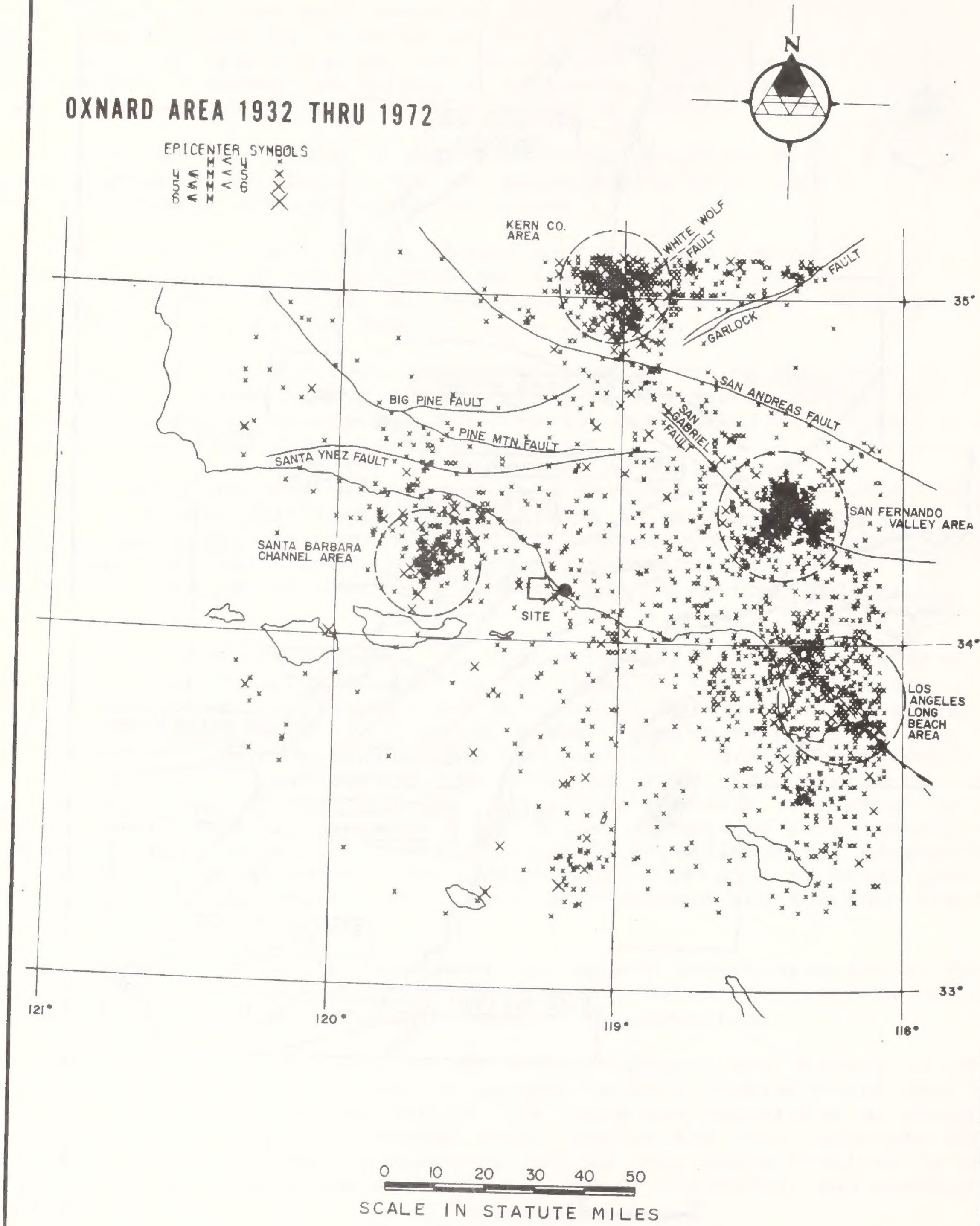
There are very few rocks of the early Paleozoic Era exposed in the Mojave Desert region; hence, it is assumed to be a highland area that was being actively eroded to low relief. If there was deposition of sediments, they have been subsequently eroded away. During the late Paleozoic Era, the area was submerged under a widespread shallow sea, which resulted in the accumulation of great thicknesses of siltstone, sandstone, and carbonate rocks.

The Mesozoic Era was a period of diverse geologic activity. Widespread uplift, deformation, and erosion was followed by a period of violent volcanic activity. The volcanism was followed by magmatic intrusion of granitic-type rock which occurred during a period of orogeny or mountain


N
Bishop
1872 Owens Valley earthquake
?
U
D (23')
(16')
Bakersfield
1952 Kern County earthquake
D
U(2')
(2')
Baker
(3")
1947 Manix earthquake
(?)
1857 Fort Tejon earthquake
1971 San Fernando earthquake
Santa Barbara
?
SITE
Los Angeles
San Bernardino
1899 San Jacinto earthquake
?
1968 Borrego Mountain earthquake
1951 Superstition Hills earthquake
Brawley
1940 Imperial Valley earthquake
(15')
Yuma
San Diego
1934 Colorado delta earthquake
?
Ensenada
1956 San Miguel earthquake
U(3')
D
(3')
0
50
100
SCALE IN STATUTE MILES

Source: Dames and Moore, 1975, Vol. II

Figure 8.2.5-3 **Historic fault breaks, southern California region**



Source: Dames and Moore, 1975, Vol. II

Figure 8.2.5-4 Instrumental locations of earthquake epicenters in site area, 1932-1972

building. The intrusion metamorphosed much of the existing Precambrian and Paleozoic sedimentary rocks. Large-scale thrust faulting occurred during late Mesozoic time.

There is a long gap in the geologic record between the end of the Mesozoic Era and Miocene time. The absence of early Tertiary sediments in the Mojave Desert area and their presence both north and south of it indicate that the block stood above the surrounding areas and was subject to erosion during this time. Hewett also believes that the movement on the Garlock fault began soon after the close of the Mesozoic orogeny. By middle Miocene, the highland that had persisted through the early Tertiary had been worn down to a surface of moderate to low relief. Miocene water-laid sediments are the most widespread of the Tertiary rocks in the Mojave block, although volcanic rocks are also present. Crustal movements during the Miocene were characterized by broad regional warping and localized downwarping of sedimentary basins.

The Pliocene was a period of renewed orogeny and thrust faulting. The older Miocene basins had become filled, and continued downwarping of localized areas created new basins for the deposition of Pliocene sediments. Areas that were uplifted during the Pliocene orogeny were being actively eroded and were reduced to relatively low relief by the end of the Pliocene.

By Pleistocene time, the area had been eroded to a relatively flat plain. Localized uplift and erosion still occurred in some areas. There was intermittent volcanic activity, as evidenced by basalt flows and cinder cones. A northwest-trending fault zone was active. The southern portion of the area received alluvial sediments from the San Bernardino Mountains to the south.

Soils

Surface Conditions

The plant site is essentially flat except for a sand berm at the south end at the property which rises above the general site grades. Site elevations range from about 5 feet in the southwest to slightly over 9 feet in the northeast.

Drainage is relatively good in the eastern half of the site due to the surface elevation and a surface gradient of about 0.5% toward the southwest. This area is leased on a year-to-year basis and is planted in flowers which are not irrigated. The western half is low lying and poorly drained. It is covered with natural low vegetation.

The surface soils in the area are of the Camarillo-Hueneme-Pacheco association. These soils are silty sands to silty clays and, from an agricultural standpoint, are some of the most productive in the Ventura area. They are used primarily for growing irrigated vegetables, field crops, lemons, and strawberries.

Most of the agriculturally developed areas are artificially drained. In undrained areas, the water table is generally within 2 feet of the ground surface during the irrigation season. Groundwater levels beneath the cultivated portions of the site were observed in October, 1973, to be between Elevation 1.5 and 2.0 (about 7 feet below grade). However, this was not during the irrigation season. The soils generally contain soluble salts, with greater concentrations in the poorly drained portions of the site. The silty near-surface soils may exhibit moderate shrink-swell properties.

The LNG transfer system will be above ground from the trestle to the plant site. The soils encountered from the plant site to the beach berm will be those of the Camarillo-Hueneme-Pacheco association. Beach sand will be encountered from the pier to the beach berm.

The seawater exchange pipeline from the Ormond Beach Generating Station will encounter the Camarillo-Hueneme-Pacheco association along the entire route.

Subsurface Conditions

Subsurface conditions vary somewhat across the site and can be described generally as follows:

Soil Layer 1. From the surface to about 14 to 20 feet--alternating layers of loose silty fine sand and soft to medium clayey and sandy silt.

Soil Layer 2. The next 60 feet--dense to very dense clean and silty fine sand, with occasional layers of stiff to very stiff clayey silt up to 5 feet thick.

Soil Layer 3. The next 50 feet--alternating layers of stiff to very stiff clayey silt and dense clean and silty sand.

Soil Layer 4. Very dense clean and silty sand with some gravel to the depths explored (maximum depth = 220 feet). This layer constitutes the upper portion of what is known hydrologically as the Oxnard Aquifer.

These conditions are subject to verification during future foundation investigations for specific structures.

Seismic Stability

Due to their grain size and density, the near-surface silty sands (layer 1) would be the on-site soils most susceptible to liquefaction. Based on extensive laboratory testing, which was conducted in conjunction with the foundation investigation, the sandy soils below Elevation -5 to -11 feet (Layer 2) would be unlikely to liquefy under design earthquake conditions.

Transverse Ranges Province

The dominant soil type in this area is the Rockland-Rough broken land association. The soils are either extremely thin, <12 inches, or nonexistent. Permeability is very low and runoff is rapid. These two factors indicate that the water erosion potential is severe, especially in the steeper terrain.

Western Mojave Province

Mojave-Rogers Dry Lake Area--The Adelanto-Hesperia-Rosamond-Garlock associations constitute the dominant soil groups that the proposed pipeline will cross. Well-drained, brownish to gray brown coarse sandy loam soils form on the gentle to moderate sloping alluvial deposits. These soils exhibit rapid permeability and medium to slow runoff characteristics. Finer-grained clay loam subsoils generally form in the low basins containing Rosamond and Rogers dry lakes. Due to slow runoff and relative impermeability of the subsoils, these areas are commonly covered with standing water after rains. The shrink-swell potential of these soils is graphically illustrated by the desiccation fissures that have formed on the dry lake beds. A thin veneer of wind-blown sand covers portions of the area adjacent to these lakes. As in most desert soils, organic content is generally very low. Soil depth for the region commonly exceeds 5 feet. The water and wind erosion potential vary from slight to severe, with wind erosion being the potentially greater problem. Water erosion problems are generally restricted to the steeper alluvial fans adjacent to the mountains.

Hi Vista - El Mirage Area

Soils within this region develop on gentle to moderately sloping alluvial, granitic, and metamorphic bedrock terrains. Because of differences in slope and composition of the parent rock material, the soil characteristics are moderately diverse. The soil groups are inferred to be part of the Calvista-Hi Vista-Cajon associations. Field observations within the area indicate the soils range from 5-feet thick in the basins to less than 1-foot thick in the Hi Vista upland area. The Hi Vista upland soils are pale brown sandy loam horizons that are derived from granular weathered granitic rock. Basin soils are light yellowish brown, well-drained loamy fine sand with moderately slow to moderately rapid subsoil permeability. Runoff is slow and the water erosion potential is slight. The wind erosion potential is moderate.

The soils found between El Mirage Dry Lake and the Shadow Mountains are well-drained sandy loam horizons that developed on a narrow, steep alluvial fan deposit. Subsoil permeability is moderately slow to moderately rapid, and runoff is slow to medium. Wind and water erosion potential is slight to high. The El Mirage lake bed area presents problems of a high shrink-swell potential and occasional standing water. Subsoil permeability is slow. The lower slopes of the Shadow Mountains are covered with thin, sandy, wind-deposited soils.

Water Resources

The regasification plant and terminal property is situated in a low-lying coastal area. Principal streams do not flow near or affect the property. Aquifers are at great depths, isolated from the land surface by impervious formations.

Surface Water Hydrology

The property is located in the Oxnard Plain, a featureless coastal valley floor. Precipitation is seasonal, occurring mainly in the December through March period. Annual rainfall averages 10 inches.

The area was originally intensely cultivated for row crops, but is becoming partially urbanized. This urbanization has resulted in a channeling of the drainage through such structures as blind culverts. Because the gradient is less than 15 feet per mile, runoff is slow, and artificial drains have been constructed for the purpose of relieving ponded water conditions in agricultural areas. One of these drains (Oxnard Industrial Drain) is located approximately 1,800 feet northwest of the proposed site and essentially drains the east half of the Oxnard urban area.

The drain is not entirely adequate for handling runoff and occasionally overflows onto the area northwest of the site during some wet seasons.

The property elevation ranges from about 5 to 10 feet above sea level and is less than 1/2 mile from the coast. Drainage and flooding are therefore influenced by tidal conditions.

The Santa Clara River, a major stream, empties into the ocean 8 miles north of the property. This distance is sufficiently far that flooding conditions on this river will not affect the site.

Chemical quality of the surface waters draining the site and surrounding areas is not monitored. The water is highly mineralized because of discharges from surrounding agricultural and urban areas, which use groundwater. During wet seasons, runoff into the drains dilutes the stream waters. Surface waters in the Oxnard Plain area are not used for water supply principally because of inadequate runoff and storage potential.

Groundwater Hydrology

Intensive groundwater pumping for irrigation and the resultant seawater intrusion into aquifers beneath Oxnard Plain has prompted detailed investigation of groundwater conditions by the California Department of Water Resources.

Aquifers beneath the Oxnard Plain are Pleistocene and Recent granular sedimentary units associated with the development of the Santa Clara River, its floodplain, delta, and estuary. The aquifers dip gently toward the coast and are present to depths of 3,000 feet or more. The aquifer units are confined under artesian pressure and are separated from one another by more or less continuous layers of silt or clay. The aquifers merge northwest of Oxnard, where they receive recharge from floodplain deposits of the Santa Clara River. Groundwater movement is normally toward the coast, and natural discharge is offshore through submerged outcrop areas.

The uppermost aquifers--the Oxnard and the Mugu--are capable of producing large quantities of water. They have been developed extensively by large-capacity irrigation wells. Consequently, a substantial amount of data are available for them. Because there has been no need to obtain water from deeper aquifers, the information available for these aquifers is limited to results from a few test wells.

The 3 principal aquifers in the property area are the Oxnard, Mugu, and Fox Canyon. According to Department of Water Resources data, the Hueneme aquifer thins out west of the property and apparently is not present below the property.

Unpublished data compiled by the Ventura County Flood Control Division (VCFCD) from oil well logs indicate the possible existence of a clay zone at depth in the vicinity of the proposed site. A cross section through the site area constructed by VCFCD from the additional data indicates that the Mugu and Upper Fox Canyon aquifers may be thin or nonexistent under the proposed site. The existence of the Grimes Canyon aquifer beneath the property has not been definitely established. The property is isolated from the aquifer system by a clay layer and is downstream from the recharge areas.

In the property area, groundwater elevations have been measured since 1915. Prior to 1920, the aquifers were confined under sufficient artesian pressure to cause wells to flow naturally. Pumping for subsequent irrigation caused water levels to decline gradually to a low of 40 feet below sea level in the 1960's. Due to pumping decrease, water levels have recently begun to rise, and groundwater in the site area is now approximately at sea level.

Groundwater in the Oxnard Plain is predominantly a calcium-sodium sulfate type. Dissolved solids are about 1,000 mg/1. The chemical analysis of water sampled in 1971 from a well on the eastern edge of Oxnard follows:

Well No.	IN/22W-3F4	(Values in ppm)	
Calcium	146	Bicarbonate	277
Magnesium	50	Sulfate	443
Sodium	96	Chloride	52
Potassium	5.5	Nitrate	14
Total Hardness	571		
Dissolved Solids	1,024		

The water is suitable for most irrigation uses. It is highly mineralized and very hard, according to most public health standards, but with treatment for hardness can be made satisfactory for domestic use. The populations of both Oxnard and Port Hueneme, as well as irrigators, use local groundwater.

The water level drawdown caused by pumping has resulted in a reversal in gradient, such that beginning in the late 1940's seawater has invaded aquifers near the coast. The principal intrusion has occurred at Port Hueneme.

Palmdale-Hinkley

Water Quality--Because of the intermittent nature of streams in this drainage region, there are no data on surface water quality. However, stream water quality is generally good during periods of high flow in the winter and diminishes as flow diminishes in the spring. Groundwater quality degradation may occur due to the introduction of State Project Water that will accelerate the concentration of salts in the groundwater basin.

Antelope Valley Drainage Region

Antelope Valley, the westernmost portion of the Mojave Desert, receives very little precipitation. Precipitation decreases away from the Palmdale area and the Sierra Palona mountains toward the towns of Adelanto and Hinkley. As a result, streamflow is diminished and groundwater is generally less abundant and of poorer quality.

Upper Mojave River Drainage Region

This region extends from the Shadow Mountains east of El Mirage Dry Lake to Hinkley. This region is a part of the Mojave Desert and is similar to the Antelope Valley region. The first 60 miles of the pipeline route fall entirely within the Santa Clara River Basin. The basin comprises that portion of Los Angeles County north of the San Gabriel Mountains draining into the Santa Clara River, and nearly all of Ventura County, except two small areas in the northeast and northwest corners of the county. The basin is characterized by rugged mountains in the north and east, consisting of the Tehachapi, Santa Ynez, San Gabriel, Topatoga and Santa Monica Ranges, where numerous ridges rise above 6000 feet MSL and some above 8000 feet MSL. In the south and west, they dwindle to rolling hills, alluvial valleys, and coastal floodplains. The area is drained by three principal stream systems consisting of the Ventura River, Santa Clara River, and Calleguas Creek. All empty into the ocean along the Ventura County coast.

The basin extends inland from the coast approximately 56 miles, its maximum east-west dimension being about 80 miles. The entire basin covers about 2267 square miles. The surface area of water-bearing sediment in the basin is about 669 square miles, of which 202 square miles are in Los Angeles County and 467 square miles in Ventura County.

The region to be occupied by the proposed pipeline obtains its water from several sources. The quality varies somewhat depending on the exact locale and source of water.

Lake Piru

The United Water Conservation District operates Lake Piru, the second largest surface reservoir in Ventura County, with a 101,225 acre-feet storage capacity, regulated by Santa Felicia Dam. District territory includes the Santa Clara River watershed, as well as important groundwater basins in the Oxnard Plain and in Pleasant Valley.

The replenishment of the reservoir is from direct precipitation, natural runoff, and Pyramid Reservoir releases from Los Angeles County--part of the State Water Project. The "safe yield" of Lake Piru Reservoir is approximately 15,000 acre-feet/year, although the lake is presently operating far below capacity.

The lake water is considered to be very hard but acceptable for most industrial uses. The District expects that future releases of relatively high quality water from Pyramid Reservoir will improve the quality of the lake water by considerably lowering the total dissolved solids (TDS) concentration.

Saticoy Well Field

Water derived from the United Water Conservation District's Saticoy well field is supplied to various agencies on the Oxnard Plain and in Pleasant Valley. However, the high TDS concentrations of this water indicate that its quality is only "marginal" for domestic use.

Calleguas Municipal Water District

The Calleguas Municipal Water District, located in the southern portion of Ventura County, obtains all of its water from the Metropolitan Water District of Southern California, via the State Water Project. The District's current intake capacity, 90 cubic-feet/second (cfs), is already being used during summer high demand periods. However, the Metropolitan Water District currently is constructing a 260 cfs line to the District, which will increase intake capacity to 350 cfs in the near future. The imported water is of excellent quality, with very low TDS concentrations, and there is no limit to the District's entitlement to this water. Lake Bard Reservoir, with a storage capacity of 10,500 acre-feet, is operated by the District as a terminal storage facility for imported State Project water.

Groundwater beneath the Oxnard Plain has a high average TDS concentration, making it acceptable for irrigation but only marginal for domestic and industrial use. Within the Oxnard Plain, serious landward intrusion of sea water is occurring in the Oxnard and Mugu Aquifer Zones.

The Ventura River subunit, the mountainous unit in the southwest part of the basin, totals about 150,000 acres, with valleys along Matilija and San Antonio Creeks and the Ventura River that drain the area to the ocean. Free groundwater conditions prevail throughout the upper part of the subunit. The lower Ventura River subunit is underlain by nonwater-bearing formations and is confined. Two important reservoirs are in the area: Matilija Reservoir, northwest of Ojai, has a capacity of 3,900 acre-feet; and Casitos Reservoir (the largest operational reservoir in the basin) has a capacity of 250,000 acre-feet.

The Calleguas-Conejo Creek subunit covers 194,020 acres in the southern part of the basin. Drainage from the area reaches Calleguas Creek by way of Arroyo Simi, Arroyo Las Posas, Conejo Creek, and the Revolon Slough. Calleguas Creek flows into Mugu Lagoon.

The Santa Clara River subunit is the largest of the three drainage systems and is located almost completely within Los Angeles and Ventura Counties. The area is comprised of 1,092,450 acres of mountains and valleys. Mountains exist throughout the area, except in the Oxnard Plain. The principal valley is that of the Santa Clara River, which has formed a broad floodplain from the Saugus area to the sea. Castaic, Piru, Sespe, and Santa Paula Creeks are the major tributaries of the river and drain areas north of it. The Oxnard Plain was formed as a large coastal delta of the Santa Clara River. Groundwater in the interior area is unconfined; groundwater in the aquifers under the Oxnard Plain, however, is confined except for scattered perched zones of water.

Aquifers beneath the Oxnard Plain are Pleistocene and Holocene granular sedimentary units associated with the development of the Santa Clara River, its floodplain, delta, and estuary. The aquifers dip gently toward the coast and are present to depths of 3,000 feet or more. The aquifer units are confined under artesian pressure and are separated from one another by more or less continuous layers of silt or clay. The aquifers merge northeast of Oxnard, where they receive recharge from floodplain deposits of the Santa Clara River. The uppermost aquifers, the Oxnard and the Mugu, are capable of producing large quantities of water. They have been developed extensively by large-capacity irrigation wells.

Groundwater movement normally is toward the coast, and natural discharge is offshore through submerged outcrop areas. Groundwater in the Oxnard Plain is predominantly a calcium-sodium sulphate type. Dissolved solids are about 1,000 milligrams per liter. The water is suitable for most irrigation uses. It is highly mineralized and very hard according to most public health standards but, with treatment for hardness, the water has been made satisfactory for domestic use. The municipalities of both Oxnard and Port Hueneme, as well as irrigators, use local groundwater.

The total population of the basin in 1970 was 439,000, of which 58,000 were in Los Angeles County and 381,000 were in Ventura County. The 1970 water demand in the basin for municipal and industrial purposes was 80,000 acre-feet, while demand for agricultural purposes was 260,000 acre-feet.

As the pipeline system leaves the vicinity of La Vista station, it parallels the foothills to Arroyo, Colorado, where it begins to rise in elevation. Drainage along the line from La Vista station to Fox Canyon is south to the Oxnard Plain through Beardsley, Washington, and a small, unnamed wash south of Mesa school.

Drainage from M.P. 18 to 19 is into Coyote Canyon, then to Calleguas Creek through Arroyo Las Posas. From M.P. 19 to 33, the pipeline system parallels the south slopes of Oak Ridge where drainage is through a network of canyons and finally into Calleguas Creek through Arroyo Las Posas and Arroyo Simi.

Between M.P. 33 and 34, the pipeline alignment crosses Oak Ridge and trends along its north slope. Drainage from M.P. 34 to 38.5 is north to the Santa Clara River through Tapo Canyon. Drainage from M.P. 38.5 to 41 is north to the Santa Clara River through Salt Canyon. Between M.P. 41 and 44, drainage is to the Santa Clara River through Potrero Canyon. From approximately M.P. 44 to 46, drainage is to the southeast into the South Fork of the Santa Clara River through Pico Canyon. Between M.P. 46 and 51.5, all drainage is directly into the South Fork of the Santa Clara River.

Drainages along the route from Quigley Canyon Station into the Sierra Pelona (Mint Canyon and Aqua Hauser Canyon) are also tributaries of the Santa Clara River. As the route crosses the Sierra Pelona mountains, the unnamed drainage paralleling the route into Palmdale is diverted into Amargoza Creek, which eventually drains into Rosamond Lake, a dry lake. The remainder of the route into Hinkley crosses dry washes or ephemeral streams. At Palmdale the route crosses the California aqueduct. Two reservoirs in the vicinity of the pipeline at Palmdale are Bouquet Reservoir, west in the Sierra Pelona mountains, and Lake Palmdale, just south of Palmdale.

Vegetation and Wildlife

Field reconnaissance of the proposed pipeline corridor indicates that a variety of plant and animal species occur or would be expected to occur along the route.

Plant species observed include trees, shrubs, and herbaceous species, Table 8.2.5-2. Additional species of plants (primarily annuals) would be expected to be observed during a more detailed survey.

Vertebrate animal species observed (Table 8.2.5-3) include a variety of birds and mammals and a few reptiles and fish. In addition, a number of other species would be expected to occur, at least on a transient basis, along the pipeline route.

Communities and Ecosystems

The marine environment associated with the Oxnard terminal location supports a complex of species comparable to that of Point Conception. Section 8.2.1 includes a full discussion.

The pipeline route will cross, or pass adjacent to, five vegetation associations containing elements typical of natural as well as agricultural vegetation common in southern California:

- Agriculture
- Coastal sage scrub/chaparral
- Oak woodland
- Grassland
- Riparian

Table 8.2.5-2 Plant species observed during field reconnaissance of the proposed pipeline route

Scientific Name	Common Name
GYMNOSPERMAE	
CUPRESSACEAE	
Cupressus macrocarpa	Monterey cypress
PINACEAE	
Pinus spp.	Pine
Cedrus deodara	Deodar cedar
TAXODIACEAE	
Sequoia sempervirens	Coastal redwood
ANGIOSPERMAE	
DICOTYLEDONAE	
AIZOACEAE	
Mesembryanthemum eduli	Ice plant (Hottentot fig)
ANACARDIACEAE	
Rhus trilobata	Squaw bush
Rhus ovata	Sugar bush
Rhus diversiloba	Poison oak
Schinus molle	Pepper tree
CACTACEAE	
Opuntia sp.	Prickly pear cactus
CAPPARIDACEAE	
Isomeris arborea	Bladder pod
CHENOPODIACEAE	
Atriplex cf. *breweri*	Brewer's saltbush
Atriplex canescens	Four wing saltbush
Atriplex leucophylla	Salt bush
Atriplex patula (spp. hastata)	Coastal orache
Salsola kali	Russian thistle (pestifer)

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[1] Scientific nomenclature after Munz and Keck, 1959.

(continues)

Table 8.2.5-2 Continued

Scientific Name	Common Name
COMPOSITAE (ASTERACEAE)	
Ambrosia sp.	Ragweed
Ambrosia psilostachya	Western ragweed
Artemisia californicus	California sagebrush
Baccharis pilularis var. consanguinea	Chaparral broom (coyote brush)
Baccharis glutinosa (viminea)	Mule fat
Centaurea melitensis	Tocalate
Centaurea repens	Russian knapweed
Centaurea solstitialis	Barnaby's starthistle
Circium sp.	
Cotula coronopifolia	Brass buttons
Eriophyllum confertifolium	
Haplopappus squarrosus	Goldenbush
Helianthus sp.	Sunflower
Lepidospartum squamatum	Scale broom
Senecio douglasii	Groundsel
Stephanomeria sp.	Stephanomeria
Xanthium sp.	Cocklebur
CONVOLVULACEAE	
Convolvulus cyclostegium	Bindweed
CRUCIFERAE (BRASSICACEAE)	
Brassica nigra	Black mustard
Raphanus sativus	Wild radish
Sisymbrium altissimum	Tumble mustard
EUPHORBIACEAE	
Croton californicus	Croton
Ricinus communis	Castor bean
FAGACEAE	
Quercus agrifolia	Coast live oak
Quercus lobata	California white oak

(continues)

Table 8.2.5-2 Continued

Scientific Name	Common Name
GERANIACEAE	
Erodium sp.	Storksbill (filaree)
HYDROPHYLLACEAE	
Eriodictyon crassifolium	Yerba santa
LABIATAE	
Salvia apiana	White sage
Salvia leucophylla	Purple sage
Salvia mellifera	Black sage
LEGUMINOSAE (FABACEAE)	
Lupinus sp.	Bush lupine
Lotus scoparius	Deerweed
Melilotus albus	Sweet clover
Robinia pseudo-acacia	Black locust
MALVACEAE	
Malacothamnus fasciculatus	Malacothamnus
Malva sp.	Mallow (Cheeseweed)
MYRTACEAE	
Eucalyptus sp.	Eucalyptus
NYCTAGINACEAE	
Mirabilis laevis	Four o'clock
POLYGONACEAE	
Eriogonum fasciculatum	California buckwheat
Eriogonum sp.	Buckwheat
Rumex sp.	Dock
RHAMNACEAE	
Adenostoma fasciculatum	Chamise
Ceanothus crassifolius	Hoaryleaf ceanothus
Cercocarpus betuloides	Mountain mahogany
Prunus ilicifolia	Holly-leaved cherry
Rhamnus crocea	Redberry

(continues)

Table 8.2.5-2 Continued

Scientific Name	Common Name
ROSACEAE	
Adenostoma fasciculatum	Charmise
Heteromeles arbutifolia	Toyon
RUBIACEAE	
Galium angustifolium	Chaparral bedstraw
SALICACEAE	
Populus fremontii	Fremont's cottonwood
Populus trichocarpus	Black cottonwood
Salix sp.	Willow
SCROPHULARIACEAE	
Mimulus sp.	Monkey flower
SOLANACEAE	
Nicotiana glauca	Tree tobacco
Solanum douglasii	Nightshade
TAMARICACEAE	
Tamarix sp.	Tamarisk (Salt cedar)
UMBELLIFERAE (APIACEAE)	
Foeniculum vulgare	Sweet fennel
UTRICACEAE	
Urtica holosericea	Stinging nettle
AGAVACEAE	
Yucca whipplei	Spanish bayonet
GRAMINEAE (POACEAE)	
Avena fatua	Wild oat
Bromus mollis	Soft chess
Bromus rigidus	Ripgut grass
Bromus rubens	Red brome
Danthonia californica	
Digitaria sp.	Crabgrass
Distichlis spicata	Salt grass

(continues)

Table 8.2.5-2 Continued

Scientific Name	Common Name
Elymus cinereus	
Elymus caput-medusae	Medusa head wild rye
Hordeum sp.	Wild barley
Hordeum stebbinsi	Foxtail grass
Lolium sp.	Rye grass
Lolium multiflorum	Italian rye grass
JUNCACEAE	
Juncus acutus	Spiny rush (wire grass)

Source: Dames and Moore, 1975, Vol. V

Table 8.2.5-3 Vertebrate animals observed or expected[1] to occur along the proposed pipeline route

Scientific Name[2]	Common Name
AMPHIBIANS	
PLETHODONTIDAE	
*_Batrachoseps attenuatus_	California slender salamander
PELOBATIDAE	
*_Scaphiopus_ sp.	Spadefoot toad
BUFONIDAE	
*_Bufo_ sp.	Toad
HYLIDAE	
*_Hyla_ sp.	Treefrog
*_Rana_ sp.	Frog
REPTILES	
IGUANIDAE	
Sceloporus occidentalis	Western fence lizard
*_Uta stansburiana_	Side-blotch lizard
*_Phrynosoma coronatum_	California horned lizard
SCINCIDAE	
*_Eumeces skiltonianus_	Western skink
TEIIDAE	
*_Cnemidophorus tigris_	Western whiptail
ANGUIDAE	
*_Gerrhonotus multicarinatus_	Southern alligator lizard
COLUBRIDAE	
*_Diadophis punctatus_	Ringneck snake
*_Masticophis_ sp.	Racer
*_Pituophis melanoleucus_	Gopher snake

(continues)

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[1] Species expected to occur, but not observed, along the route indicated by asterisk.

[2] Scientific nomenclature after Hunsaker, 1970.

Table 8.2.5-3 Continued

Scientific Name	Common Name
*Lampropeltis getulus	California kingsnake
*Thamnophis sp.	Garter snake
CROTALIDAE	
*Crotalus sp.	Rattlesnake
BIRDS	
CATHARTIDAE	
Cathartes aura	Turkey vulture
*Gymnogyps californianus	California condor
ACCIPITRIDAE	
Elanus leucurus	White-tailed kite
*Accipiter cooperii	Cooper's hawk
Buteo jamaicensis	Red-tailed hawk
Buteo lineatus	Red-shouldered hawk
*Buteo swainsoni	Swainson's hawk
*Circus cyaneus	Marsh hawk
FALCONIDAE	
Falco sparverius	Kestrel
PHASIANIDAE	
Lophortyx californicus	California quail
COLUMBIDAE	
Zenaidura macroura	Mourning dove
CUCULIDAE	
Geococcyx californianus	Roadrunner
TYTONIDAE	
*Tyto alba	Barn owl
STRIGIDAE	
*Otus asio	Screech owl
*Bubo virginianus	Great horned owl
*Speotyto cunicularia	Burrowing owl

(continues)

Table 8.2.5-3 Continued

Scientific Name	Common Name
CAPRIMULGIDAE	
*Chordeiles minor	Common nighthawk
*Chordeiles acutipennis	Lesser nighthawk
APODIDAE	
*Aeronautes saxatalis	White-throated swift
TROCHILIDAE	
*Archilochus alexandri	Black-chinned hummingbird
*Calypte costae	Costa's hummingbird
*Calypte anna	Anna's hummingbird
*Selasphorus rufus	Rufous hummingbird
*Selasphorus sasin	Allen's hummingbird
PICIDAE	
Colaptes cafer	Red-shafted flicker
*Dendrocopos sp.	Woodpecker
TYRANNIDAE	
*Tyrannus sp.	Kingbird
*Sayornis nigricans	Black phoebe
*Sayornis saya	Say's phoebe
*Empidonax sp.	Flycatcher
ALAUDIDAE	
*Eremophila alpestris	Horned lark
HIRUNDINIDAE	
*Riparia riparia	Bank swallow
*Hirundo rustica	Barn swallow
*Petrochelidon pyrrhonota	Cliff swallow
CORVIDAE	
Aphelocoma coerulescens	Scrub jay
Corvus corax	Common raven
*Corvus brachyrhynchos	Common crow
PARIDAE	
*Parus inornatus	Plain titmouse

(continues)

Table 8.2.5-3 Continued

Scientific Name	Common Name
*_Psaltriparus minimus_	Common bushtit
CHAMAEIDAE	
Chamaea fasciata	Wrentit
TROGLODYTIDAE	
*_Troglodytes aedon_	House wren
MIMIDAE	
Mimus polyglottos	Mockingbird
*_Toxostoma redivivum_	California thrasher
TURDIDAE	
*_Turdus migratorius_	Robin
*_Hylocichla guttata_	Hermit thrush
SYLVIIDAE	
*_Polioptila caerulea_	Blue-gray gnatcatcher
*_Regulus_ sp.	Kinglet
LANIIDAE	
Lanius ludovicianus	Loggerhead shrike
STURNIDAE	
*_Sturnus vulgaris_	Starling
*_Vireo_ sp.	Vireo
PARULIDAE	
Dendroica auduboni	Audubon's warbler
PLOCEIDAE	
*_Passer domesticus_	House sparrow
ICTERIDAE	
*_Sturnella neglecta_	Western meadowlark
THRAUPIDAE	
*_Piranga ludoviciana_	Western tanager
FRINGILLIDAE	
Carpodacus mexicanus	House finch
*_Spinus tristis_	American goldfinch
*_Spinus psaltria_	Lesser goldfinch
*_Spinus lawrencei_	Lawrence's goldfinch

(continues)

Table 8.2.5-3 Continued

Scientific Name	Common Name
Pipilo fuscus	Brown towhee
*_Aimophila ruficeps_	Rufous-crowned sparrow
*_Junco oreganus_	Oregon junco
*_Spizella passerina_	Chipping sparrow
Zonotrichia leucophrys	White-crowned sparrow
*_Zonotrichia atricapilla_	Golden-crowned sparrow
*_Passerella iliaca_	Fox sparrow
*_Melospiza melodia_	Song sparrow
MAMMALS	
DIDELPHIDAE	
*_Didelphis marsupialis_	Opossum
SORICIDAE	
*_Sorex ornatus_	Ornate shrew
TALIPIDAE	
*_Scapanus latimanus_	Broad-footed mole
VESPERTILIONIDAE	
*_Myotis_ sp.	Bat
*_Eptesicus fuscus_	Big brown bat
*_Lasiurus_ sp.	Bat
MOLOSSIDAE	
*_Tadarida_ sp.	Free-tailed bat
LEPORIDAE	
Sylvilagus auduboni	Audubon's cottontail
*_Sylvilagus bachmani_	Brush rabbit
Lepus californicus	Black-tailed jack rabbit
SCIURIDAE	
Otospermophilus beecheyi	California ground squirrel
GEOMYIDAE	
*_Thomomys bottae_	Southern pocket gopher
HETEROMYIDAE	
*_Perognathus_ sp.	Pocket mouse

(continues)

Table 8.2.5-3 Continued

Scientific Name	Common Name
*Dipodomys agilis	Pacific kangaroo rat
CRICETIDAE	
*Peromyscus boylii	Brush mouse
*Peromyscus californicus	California mouse (white-footed mouse)
*Peromyscus maniculatus	Deermouse
*Reithrodontomys megalotis	Western harvest mouse
*Microtus californicus	California vole
*Neotoma spp.	Woodrat
CANIDAE	
Canis latrans	Coyote
*Urocyon cinereoargenteus	Gray fox
PROCYONIDAE	
*Procyon lotor	Raccoon
MUSTELIDAE	
*Mustela frenata	Long-tailed weasel
*Spilogale putorius	Spotted skunk
*Taxidea taxus	Badger
FELIDAE	
*Lynx rufus	Bobcat
CERVIDAE	
Odocoileus hemionus	Mule deer
FISH	
POECILIIDAE	
Gambusia affinis	Mosquitofish
Carassius auratus	Goldfish

Source: Dames and Moore, 1975, Vol. V

Agriculture--Agricultural plantings of row crops and orchards occur and are the dominant type along the route in the Oxnard Plain, with additional agriculture in various other areas. The row crops include a wide variety of vegetables, as well as commercial flowers. Orchard crops include citrus, avocados, and walnuts. Horticultural roadside plantings are considered to be in the agricultural category and include eucalyptus, tamarisk (salt cedar), and Monterey cypress and occur at various locations along the pipeline route. Additional horticultural species in close proximity to the pipeline include coastal redwood, deodar cedar and various pines. Approximately 31 percent of the proposed pipeline route passes through agriculturally vegetated areas.

Coastal Sage Scrub/Chaparral--The natural vegetation along the proposed corridor is dominated (43 percent) by a mosaic of coastal sage scrub and chaparral vegetation. The vegetative composition changes with slope exposure and comprises a mixed coastal sage scrub/chaparral association. The common coastal sage scrub dominants in the mixed vegetation include California buckwheat, California sagebrush, black sage, purpose sage, white sage, and golden bush. The chaparral-covered slopes are dominated by chamise (often occurring in almost pure stands) and ceanothus, with redberry, toyon, and sugarbush as common associations.

Oak Woodland--Oak woodland vegetation occurs along about 6 percent of the pipeline route. This vegetation type also is variable in composition, with an overstory dominated by valley oak, coast live oak and, in places, a mix of these two species. The understory vegetation varies from grass-dominated cover to a cover dominated by chaparral and coastal sage scrub elements.

The oak woodland vegetation has a savannah-like aspect in some areas such as the higher elevations of Oak Ridge and on the lower rolling terrain on the southwest portion of Potrero Canyon. In many of the canyon areas along the north slope of the Santa Susana Mountains and Oak Ridge, the oaks form a relatively closed canopy. In the Happy Camp Canyon portion of the route, the proposed pipeline will pass through riparian oak woodland as it crosses intermittent streams that join the main canyon.

Grassland--Grassland vegetation occurs in various locations along the length of the pipeline corridor, comprising about 17 percent of the route. Much of the grassland is a result of clearing the coastal sage scrub/chaparral vegetation for grazing purposes or appears to be a result of old field succession. Much of this disturbance-related grassland is scattered throughout areas dominated by coastal sage scrub/chaparral. In other areas, such as Oak Ridge, the grassland may be a natural community, modified by grazing pressures and introduced species. This may also be true of parts of Potrero Canyon. The grassland areas on Oak Ridge and in Potrero Canyon provide an understory for the oak woodland as described above.

Riparian--Riparian vegetation occurs at a number of locations along the proposed corridor comprising about 3 percent of the route. These riparian areas are primarily associated with intermittent streams, which occur from Beardsley Wash to Oro Fino Canyon and include the South Fork of the Santa Clara River. The species associated with riparian areas along the route are variable and include black cottonwood, willow, coast live oak, eucalyptus, peppertree, mulefat, cocklebur, stinging nettle, dock and various grasses, among others. In addition to the intermittent stream vegetation, a riparian habitat associated with drainage channels in the Oxnard Plain also is crossed by the proposed pipeline. This drainage channel vegetation includes dock, brassbuttons, watercress, wire grass, Bermuda grass, ragweed, sweet clover and stinging nettle, among others. The vegetation in these channels appears to be modified by periodic control methods using oil and/or herbicide treatments.

Wildlife

The warmer environment in the vicinity of Oxnard is comparable to that described at Point Conception. The various faunal elements of that ecosystem are described in Section 8.2.1 relative to the prime route. However, a feature unique to the Oxnard location is Anacapa Island. This island, which composes part of the Channel Islands National Monument, is the traditional nesting area of a colony of the endangered brown pelican.

Because of the varied habitats available along the pipeline routes, a wide variety of animal species is expected to occur within the proposed pipeline corridor. Such species may include those which live within the proposed right-of-way and those which may use it only on a transient basis. Some of the small mammal species expected to occur within the proposed corridor are the whitefooted mouse, pocket mouse, kangaroo rat, woodrat, vole, and cottontail rabbit, among others. Larger species may include grey fox, raccoon, bobcat, skunk, weasel, badger, and opossum, among others. During the field reconnaissance, mule deer were observed in Happy Camp Canyon and ground squirrels were observed along most of the route. Coyote scat was noted in the Beardsley Wash area and the species would be expected to occur along most of the proposed route.

A limited number of bird species was identified during the field reconnaissance; however, a wide variety of species is expected to occur along the route. Species observed included Audubon's warbler, brown towhee, California quail, wren-tit, various sparrows, mockingbird, mourning dove, common raven, red-tailed hawk, red-shouldered hawk, kestrel, and white-tailed kite. A variety of other species would be expected to occur along the proposed alignment.

The western fence lizard was observed along the route; however, a number of additional reptilian species would be expected to occur within the pipeline corridor. These include the alligator lizard, side-blotched lizard, kingsnake, gopher snake, garter snake, and rattlesnake, among others.

Amphibians expected to occur but not observed along the route include species of toads, tree frogs, and true frogs.

Goldfish and mosquito fish were observed in the drainage channel that the pipeline will cross within the LNG plant site. Mosquito fish may also occur in other drainage channels crossed by the pipeline.

Unique and Other Biotic Resources

No rare or endangered species of plant were observed during the brief field reconnaissance of the proposed pipeline route, nor are rare or endangered mammals, reptiles, amphibians, or fish expected to occur along the route. However, the white-tailed kite, a bird protected by the State of California, was observed along the corridor. This species was noted in the Oak Ridge and Happy Camp Canyon portions of the route and might be expected to occur along other portions as well. The Oak Ridge-Santa Susana Mountain area is considered to be within the foraging range of the California condor, a rare, endangered, and protected species. The area probably is seldom used by the small surviving population of condors because of human activity present in the region.

Mojave Desert Province

Disturbance History of Natural Habitats--Human activities in the desert are widespread. Subdivisions have created dirt-road grids in some areas. Resort residences, small family ranches, and commercial poultry farms are scattered throughout the province. Seasonal sheep grazing is practiced in some areas.

Military and mining activities have influenced small areas intensely and large areas to lesser degrees (unexploded ordinance and small test excavations). Dirt and hard surface roads, buried pipelines and cables, and elevated electrical transmission lines criss-cross the province. In recent years, off-road vehicles have generated increasingly widespread and significant disturbances to soils and biota, especially in the vicinity of Baldy Mesa and scattered desert buttes.

Vegetation--The vegetation of this province is dominated by shrubs and consists of a mosaic of intermingled species referred to here as desert shrubland. Although many species are found throughout the area, the composition of the vegetation varies with elevation and with edaphic factors -- such as soil texture, drainage, and salt content. In mapping this shrubland, vegetation types have been established on the basis of conspicuous changes in species composition and life form.

Generally, creosote bush is dominant on well-drained, upper alluvial slopes. Joshua tree develops stands on similar, apparently well-watered slopes, and is also scattered near playas. Saltbush scrub is common on lower, fine-grained and more or less salty alluvial slopes and ground playas. It also occurs at the desert margins -- such as on the eastern slopes of the Sierra Pelona Mountains, where it intergrades with herbland. Patches of alkali sink and mesquite shrubland occur around the sand dunes and playa lakes in the vicinity of Rogers and Buckhorn Dry Lakes. Desert annuals produce sporadic cover throughout the desert during winter and spring.

Saltbush Scrub--This open scrub is composed of several species of shrubs and two bunch grasses. Both evergreen and deciduous species are present. However, the leaves of most shrubs deteriorate during extended adverse conditions. Some species (Ephedra, Hymenoclea, and others are characteristically leafless for much of the year. Generally, there is much bare ground between the almost regularly-spaced shrubs that comprise this relatively monotonous-appearing, yet subtly varying vegetation. The species composition of saltbush scrub varies spatially with soil parameters and topography. In fine-grained, poorly-drained soils, particularly on lower alluvial slopes, Atriplex species are dominant. In the vicinity of washes, rabbit brush, cheese bush, buckwheat, and golden bush are more prevalent. Indian ricegrass is common in some sandy areas, occasionally forming patches of grassland. Tetradymia and Lycium species seem more common at higher elevations, often near junipers.

Creosote Bush Shrubland--On well-drained soils throughout the desert, particularly on upper alluvial slopes, creosote bush is commonly found in a more or less regular spacing among the smaller saltbush scrub species. The occurrence of this extremely long-lived, hard, woody shrub is controlled by soil factors of drainage and alkalinity. Individual shrubs may live over a thousand years by repeated sprouting from the root crown. The plant is visited by hummingbirds and provides an important food source for desert rodents.

Joshua Tree Woodland--Joshua trees occur as scattered individuals on the lower alluvial slopes and in relatively dense stands on well-drained, upper slopes with adequate soil moisture. The understory of the woodland is mostly saltbush scrub. Creosote bush may be present, as on many coarse-grained upper slopes, or absent, as adjacent to Rogers Dry Lake. Joshua trees are also scattered in the lower juniper woodland of the nearby mountain slopes.

Mesquite Shrubland--In the vicinity of Rogers and Buckhorn Dry Lakes, well-developed stands of mesquite occur on small sand dunes. These arborescent shrubs are dependent on the subsurface moisture that accumulates in this low area. The species can tolerate high alkalinity, but also thrives in areas low in alkali. Alkali sink species are common around many of the shrubs.

Alkali Sink--The occurrence of these species is sporadic and restricted to low-lying, winter-wet patches among the desert scrub and along the margins of playas in the vicinity of Rogers and Buckhorn Dry Lakes and El Mirage Dry Lake.

Desert Annuals--This herbland vegetation is composed of both native and introduced annual species. In late March 1975 redstem filaree, fiddleneck and desert coreopsis were the most widespread species observed in well-developed stands along the pipeline route. Extensive stands of tumbleweed were encountered throughout the province, as evidenced by dead plants still rooted in soil.

Desert annual vegetation displays immense spatial and temporal variability in relation to rainfall and temperature. During unfavorable years, it may not develop; during favorable years, it may form a nearly continuous carpet over many hundreds of acres. Usually it is very uneven in terms of both cover and species composition.

In contrast to herblands in the Colorado-Sonoran desert, where considerable precipitation often falls from summer thundershowers, significant development of this vegetation occurs only in years with adequate winter and/or spring rainfall. Germination occurs in late autumn, winter and early spring. Depending on the weather, the growing season for some plants may be as long as 7 to 8 months or as short as 6 to 10 weeks.

Fauna--Compared with the other two provinces, the extreme temperature and aridity of the Mojave Desert--together with the sparse vegetation--provide very different living conditions for vertebrate animals. Many of the resident species are restricted to desert habitat and do not occur in the Tehachapi Mountains or Transverse Range provinces. Much of the distribution and ecology of these species has been explained in terms of adaptation to two conditions: intense heat and extreme aridity. As a consequence of these conditions, amphibians, which are easily desiccated, are uncommon. Birds, most of which cannot burrow to escape these conditions, are also relatively uncommon. Reptiles and mammals, most of which burrow or utilize crevices to avoid extreme climatic conditions, are relatively abundant.

In this habitat, seasonality of climate and vegetative growth is pronounced. Many birds visit the Mojave Desert only during winter, or in spring and fall during migration. For most resident species, breeding periods are restricted to a brief period in spring. To avoid hostile conditions during much of the year, many species -- such as the Mojave ground squirrel and desert tortoise -- retreat underground in a semidormant state. Rainfall patterns are highly variable between years and within a given area, resulting in large variations in vegetative growth and invertebrate populations that support vertebrates. As a consequence, vertebrate populations may fluctuate greatly in a given area.

Amphibians--Southwestern toad, California tree frog, and Pacific tree frog are the only amphibians expected in desert shrubland. Tree frogs may occur near temporary streams and springs along the border of the Mojave Desert. The southwestern toad is represented by a desert population along the Mojave River, in San Bernardino County, which parallels the pipeline route. Estivation in moist earth allows these amphibians to survive the hot, dry summer.

Reptiles--For many species of desert reptiles, characteristics of the substrate as well as vegetation are often implicated as major determinants of species distribution. Although these characteristics vary considerably over the Mojave Desert, a number of reptile species are common throughout most of the desert. Zebra-tailed lizard, western whiptail, and side-blotched lizard are common ground-dwelling lizards. The long-nosed leopard lizard occurs infrequently, often feeding on smaller lizards. Common snakes are gopher snake, glossy snake, common king snake, and Mojave rattlesnake.

Desert tortoise (a declining species) is the only native tortoise in California. It inhabits areas with low shrubs and annual plants, which are its food source. It occurs in localities where soil is compact enough to allow the excavation of burrows, into which it retreats for winter hibernation and to avoid the heat of mid-summer days.

Other species have more restrictive habitat requirements. The long-tailed brush lizard occurs almost exclusively on large shrubs, chiefly creosote bush and mesquite. In areas with a sandy substrate, which occur mainly in washes or in the vicinity of dry lakes, a number of other reptiles are common. Examples are the desert horned lizard, desert iguana, western shovel-nosed snake, and sidewinder. The California legless lizard lives in loose soil and sandy areas with plant cover; a few populations are known on the western edge of the Mojave Desert. In Joshua tree savannahs, desert night lizards commonly spend much of their lives beneath limbs and trunks of fallen Joshua trees. Banded gecko, collared lizard, chuckwalla, and speckled rattlesnake occur primarily in rocky areas such as canyons and buttes.

Lizards and desert tortoise are mainly diurnal, although they seek shade during midday in summer. Most of the snakes are nocturnal, particularly in midsummer. These animals pass the cold winter season in hibernation in burrows or crevices in rock outcrops.

Birds--Bird densities are generally low in the Mojave Desert. Resident species that occur throughout the desert are black-throated sparrow, cactus wren, LeConte's thrasher, and roadrunner. Loggerhead shrike and American kestrel often hunt in desert scrub for insects, especially where tall shrubs or artificial structures afford perches. Large predatory birds and vultures -- such as the common raven, red-tailed hawk, and turkey vulture -- range widely but usually return to cliffs for roosting and nesting. In areas where drinking water is available, mourning doves, Gambel's quail, and house finches are commonly found.

Most of the small resident bird species nest on the ground or in low shrubs. During winter a number of species from moister habitats visit the desert. Examples are white-crowned sparrows, western bluebirds, and Audubon warblers. Numerous other bird species migrate through the Mojave Desert in spring and fall.

The distribution and abundance of many bird species is highly variable in the desert. The shadscale scrub portions of the desert are used by relatively few species. Black-throated sparrow is probably the only common species in this habitat. In contrast, mesquite groves -- which are well represented north of the pipeline route on Edwards Air Force Base -- commonly harbor several species of birds, including verdin, ash-throated flycatcher, and LeConte's thrasher. Phainopeplas, which feed on mistletoe berries, may be abundant. The thorny mesquite thickets provide well-protected nesting sites and cover. Migratory birds tend to follow patches of dense vegetation. In response to the extreme spatial and temporal variability of essential habitat resources, flocking among wintering species is particularly common and localized aggregations of many of these birds sometimes may occur.

Where Joshua trees occur, several other bird species may be found. Many of these species are dependent upon or prefer Joshua trees for nesting. Examples are Scott's oriole, cactus wren, ash-throated flycatcher, common flicker, ladder-backed woodpecker, and American kestrel. These latter three species require cavities for nesting, which are afforded by Joshua trees. Also, Joshua trees provide observation perches used for hunting by the American kestrel and larger predatory birds.

High cliffs provide nesting sites for the golden eagle, red-tailed hawk, turkey vulture, and common raven; they build stick nests on rocky ledges. White-throated swift and prairie falcon nest in holes on sheer cliff faces, but generally do not nest in holes in trees. Typically, these species return to cliffs at night, even when they are not nesting.

Owing to the extreme aridity of this province, birds (and small mammals) often concentrate around aquatic features. Springs, and watering troughs; irrigated areas are visited daily in summer by flocks of mourning doves, Gamble's quail, chukar, and house finches. Since moist places often support an abundance of insects, swallows and other insectivores are frequently attracted to these areas. The concentration of animal life around moist places attracts predators such as hawks, owls, and coyotes.

Near Rosamond Dry Lake on Edwards Air Force Base, ponds exist that may attract migratory waterfowl. A major flyway for migrating waterfowl crosses this region of the Mojave Desert. During the winter months, mallard and other ducks, as well as shorebirds such as western sandpiper and willet, are expected. When playa lakes contain water, waterfowl and shorebirds may be attracted to these areas. The route passes 10-15 miles south of the Sespe Condor Refuge but should not affect the nesting or mating activities of the condor.

Mammals--Small mammals are common inhabitants of desert scrub, but are seldom seen since most species are nocturnal and retreat underground during the day to avoid extremes of temperature. Ten species of kangaroo rat and pocket mouse occur in this habitat. The ground at the base of creosote bushes and other shrubs is often extensively excavated by the denning activity of these rodents and white-tailed antelope squirrel. Common species that are widespread over the Mojave Desert include Merriam kangaroo rat, long-tailed pocket mouse, white-tailed antelope squirrel, cactus mouse, and southern grasshopper mouse. The black-tailed jack rabbit, the only small mammal of the desert that does not use burrows, is also widespread. A number of species of bats forage in the desert sky, roosting in caves, mines, and cliffs. The coyote is the common large mammalian predator in the desert.

Among species with more restricted distribution in the desert, the desert woodrat is common around cactus, rocky areas, and Joshua trees (which afford nest sites). In sandy areas, kangaroo rats and pocket mice are common. The Great Basin kangaroo rat is common only around patches of its primary food, shadscale. The desert cottontail deer mouse are commonly found along washes with mesquite trees. In rocky areas, kangaroo rats and pocket mice are infrequent, but the canyon mouse and desert woodrat are common. The rare Mojave ground squirrel occurs in scattered localities in creosote bush shrubland.

Economic and Sociological Factors

The socioeconomic factors considered significant in relation to the proposed project include:

- Population
- Industrial Growth and Employment
- Family Income and Retail Sales

Data and projections pertaining to these factors are discussed in this section.

For convenience, the proposed route has been divided into four general sectors and each discussed in sequence as appropriate.

- Oxnard Plain Area
- Santa Clarita Valley Area
- Los Angeles County
- San Bernardino County

Population

Oxnard Plain Area--The Oxnard Plain area lies in the southern portion of Ventura County and includes two principal communities: Oxnard and Port Hueneme.

As of January 1974, the Ventura County population was estimated at 440,459. Of these, nearly 79 percent resided within the boundaries of incorporated areas. The 1970 census reported 376,430 residents and a population density of 203 persons per square mile. Very rapid growth has marked the county, and population growth between the time of the 1970 census and January 1974, was 17 percent. The population data from the last three censuses and the Ventura County Planning Department's estimates for January 1974 for the county and for the two cities involved are presented below:

Population

Location	1950	1960	1970	1974[1]
Ventura County	114,547	199,138	376,430	440,459
Oxnard	21,657	40,265	69,783	78,866
Port Hueneme	3,024	11,067	14,296	18,718

[1] Estimate for January 1, 1974.

Sources: Bureau of the Census, 1950, 1960, 1970; Ventura County Planning Department, 1974; Social and Economic Statistics Administration, 1972.

The average annual population growth rates between the 1950, 1960, and 1970 censuses for these areas are shown below.

Average Annual
Population Growth Rate (percent)

Location	1950-1960	1960-1970
Ventura County	5.7	6.6
Oxnard	6.4	5.7
Port Hueneme	13.8	2.6

The population density data tabulated below also reflect these rates of growth.

Population Density
(persons/square mile)

Location	1970	1974[1]
Ventura County	203	238
Oxnard	3615	4086
Port Hueneme	3249	4254

[1] Estimated for January 1, 1974.

Population projections made by the County Planning Department show an expected continuation of the pattern of growth in both their low and high estimates:

Year	High	Low
1975	483,445	479,507
1980	593,369	582,934
1985	717,238	696,912
1990	835,410	799,893
1995	959,785	904,358
2000	1,080,388	1,001,673

Source: Ventura County Planning Department, 1973.

The rapid county growth rate of the past two decades is expected to diminish to about half, a more mature rate which planning is expected to influence. The projected growth rate for 1975 through 2000 ranges from 3.3 to 3.0 percent annually, while the actual average annual growth rate from 1950 to 1970 was 6.1 percent.

Major effects of the Oxnard Plain sector of the proposed pipeline will be felt by Port Hueneme and Oxnard, but will be too small to show in the total county situation. These two communities both lie within the Oxnard Urban Center which in 1970 had a population of 102,671 persons. The City of Oxnard's Planning Department's unofficial population projections for the Oxnard Urban Center are shown below.

	1970[1]	1980	1990	2000
Planning estimate	102,671	159,000	220,000	280,000
Low projection	---	132,500	169,900	195,100
High projection	---	172,900	313,500	434,500

[1] Actual.

The City of Oxnard's planning estimates project an average annual growth of 3.4 percent for the 30-year period from 1970 to 2000, approximately the same rate of growth forecast for the county.

Median age data from 1970 for the areas under consideration and for the State of Calfcrnia are tabulated below.

Location	Median Age (Years)
California	28.4
Ventura County	25.1
Oxnard	23.4
Port Hueneme	Not available

Source: Social and Economic Statistics Administration, 1972.

Generally, Ventura County has a younger population than the state; similarly, the Oxnard area has a younger populaton than the country. Port Hueneme data are not available from this source, but it is believed that the median age in that community would be close to Oxnard's - below the county and state medians.

Mountainous Areas--In the South Mountain, Oak Ridge, Santa Susana and San Gabriel mountainous areas, there are practically no populations of more than one to five persons in any areas reasonably adjacent to the proposed pipeline route. Socioeconomic analysis is considered to be unnecessary for these sparcely populated areas.

Santa Clarita Valley Area--This area comprises four unincorporated communities: Newhall, Saugus, Valencia, and Canyon Country. Population data for the valley area are reported as follows:

Date	Population
April 1950	8,045
April 1960	14,967
January 1973	57,640

Source: Newhall-Saugus-Valencia Chamber of Commerce, 1974.

The growth rate shown from April 1950 to January 1973 has been remarkable (616 percent total, approximately 9 percent per year); no single factor accounts for this growth. The Newhall-Saugus-Valencia Chamber of Commerce expects growth to continue. In this connection, it is notable that the rate of growth between April 1960 and January 1973 was between 10 and 11 percent per year, while between April 1950 and April 1960, it averaged 6.4 percent per year. Historically, growth has been accelerating significantly.

Because the boundaries of the Santa Clarita Valley are not precisely delineated, population density data are not available. For the communities in the Santa Clarita Valley, the following data are available:

Community	Population 1970	Area (Square miles)	Population Density (Persons/square mile)
Newhall	9,651	4.0	2413
Saugus	5,100	---	---
Valencia	4,243	4.0	1061

Source: Social and Economic Statistics Administration, 1972.

Densities are much lower in these communities than in Oxnard or Port Hueneme at the western end of the pipeline corridor.

The "General Plan of Los Angeles County" projected Santa Clarita Valley population growth as follows:

	Population
1970	48,000
Change 1970-1990	+82,000
1990	130,000

These are referenced as provisional projections of population growth, suggesting that they are subject to review and revision as new data develop.

No data are available on median ages for the valley area. Because Los Angeles County (of which the Santa Clarita Valley is a very small portion) is so large and diverse, data on the county would have no bearing.

Los Angeles County--Los Angeles County's population showed a 16.4% growth rate between 1960 and 1970, increasing from 6,038,771 residents in 1960 to 7,032,075 by 1970. Growth during the forecast period, 1970 to 2000, is expected to slow substantially, with a net population increase of less than 12%. The California Department of Finance Population Research Unit (1974) projects a net population decrease for the county during the decade 1970-1980, followed by a renewed population growth after 1980. Los Angeles County's population should reach 7,850,000 by 2000, up from a low of 6,963,200 forecast for 1980. The year annual growth rate of 0.4% will be considerably below the 1.6% California annual growth rate.

Some of this population growth is expected to occur in the vicinity of the proposed pipeline route. Substantial urbanization is currently taking place in the Antelope Valley communities of Lancaster and Palmdale, in the vicinity of the route, but population spillover into the desolate northeastern corner of the valley is unlikely.

San Bernardino County--Between the 1960 and 1970 census, county population increased from 503,591 to 684,072. This represented a growth of 35.8%, which exceeded the 10-year figure of 27% recorded for California as a whole, and the 16% increase for the United States. For the period 1970-2000, the Population Research Unit of the California Department of Finance (1974) projects a 57.2% population growth rate for San Bernardino County. Population is expected to reach 1,075,300 by 2000, some 391,228 more than in 1970.

In the past, the major population centers in the county have been concentrated south of the San Gabriel and San Bernardino mountains in the northeastern end of the Los Angeles Basin (that is, the San Bernardino and Pomona valleys). These areas should continue to absorb most of the new population growth in San Bernardino County. The desert region north of the San Bernardino Mountains and the area near the proposed pipeline route probably will display moderate population growth during the remainder of the century. In part, this is due to expected population spillover from the heavily urbanized Los Angeles Basin and recent trends toward residential development in the high desert. In recent years, the communities of Adelanto, Victorville, Apple Valley, Lucerne Valley, and Hesperia have experienced increased building activity -- a trend which should continue into the foreseeable future.

Industrial Growth and Employment

Oxnard Plain--The economy of the Oxnard Plain area is based primarily on agricultural production, diversified manufacturing, and government employment. The most rapid growth has been occurring in the professional, technical and kindred workers category in the county.

The effects of the Naval Construction Battalion Center at Port Hueneme are shown in the high percentage of government employees in Oxnard and the County in relation to that of the state. In other respects, considering this higher level of government employment, the profiles are not widely different from the state's.

Ventura County is currently classified as an area of substantial unemployment by the U.S. Department of Labor. As of July 1973, the seasonally adjusted unemployment rate was 4.9 percent, equivalent to some 7,000 persons.

City of Oxnard--The City of Oxnard's labor force is changing rapidly in the direction of commercial-industrial work and away from agricultural. This trend is general and is seen throughout the state and the county as agriculture shifts away from labor-intensive to mechanized operations. Higher earnings are associated with nonagricultural employment opportunities, adding impetus to the shift. Also, agricultural uses of land tend to be displaced by urban growth; as the city has expanded, agriculture has moved outside the city limits. Between 1950 and 1970, labor force participation in the farm labor category declined nearly 64 percent. At the same time, large increases in the category of professional workers were recorded. For males in the labor force, the increase was nearly 107 percent. For females, the increase was about 48 percent. Increases were also shown in the categories of sales workers and operative workers for males in the labor force.

Oxnard had 54 manufacturing establishments at the time of the 1967 Census of Manufactures. These employed 3,200 persons in total. In addition to the 54 manufacturing establishments, there were more than 60 agricultural units (growers, processors, canners, packers, and shippers) in Oxnard.

Some indication of the growth in manufacturing in Oxnard is given by the 140.8 percent increase in the value of manufactured products between the 1963 and 1967 Census of Manufacturers.

Los Angeles County--Los Angeles County has a widely diversified economic base; manufacturing, retail and wholesale trade, and the service industries represent the major employment sectors and revenue generators. The county accounts for one-third of the state's population, personal income, employment, and retail sales, and automobile sales. Furthermore, Los Angeles County's twin port facilities, Los Angeles and Long Beach, handle over one-half of California's international trade. The total civilian labor force was estimated at 3,223,900 in December 1974.

Manufacturing is the single largest employment sector, accounting for more than one-fourth of total employment in the county. In December 1974, 807,700 workers were employed by manufacturers: 264,400 in the manufacture of non-durable goods, and 543,300 in the durable goods category. Machinery and aircraft manufacturing are the most important manufacturing subsectors in the county. In 1971, the total value of industrial shipments from Los Angeles County was $25,888,000,000. The value added by manufacture, which measures the actual contribution of manufacturing to the local economy, was $13,691,800,000 in 1971. The 1971 manufacturing payroll in Los Angeles County totaled $6,985,700,000.

Retail and wholesale trade establishments employed 743,000 workers in December 1974. This represented 23.7% of the total county work force and ranked the trade industry as the county's second leading employer. Retail trade establishments employed 521,000 and wholesale trade firms 222,000. According to 1972 census data, the 59,604 retail establishments in Los Angeles County recorded total sales of $17,161,956,000. The retail trade payroll for 1972 reported sales of $32,511,150,000 in the county during 1972. The 13,318 wholesale employers generated a payroll of $1,830,712,000.

The retail and wholesale trade industries are classified as nonbasic. In contrast to manufacturing and other basic industries, which primarily produce for export markets, the nonbasic industries produce for, and supply (through imports), local consumer markets.

The service industries are the third largest employment sector in Los Angeles County. In December 1974, the 635,400 service employees in Los Angeles County represented 20.3% of the total work force. According to 1972 statistical data for selected service industries, the 70,985 service-oriented establishments in the county had total receipts of $7,075,306,000 and a combined payroll of $2,364,602,000.

Other substantial employment sectors in December 1974 were: government; finance, insurance, and real estate; transportation, communication and utilities; and construction. Government employment in Los Angeles County approached 15% of the work force with 466,700 workers. Finance, insurance, and real estate establishments and transportation, communications, and utilities were each responsible for approximately 6 percent of the total work force with 185,000 and 179,900 employees respectively. Contract construction employed 3.3% of the work force, or 102,300 workers. Total building valuation in Los Angeles County for 1973 was $2,109,700,000 -- down 5.8% from 1972.

Whereas agriculture makes a substantial contribution to the total economy in San Bernardino County, its impact on Los Angeles County is relatively insignificant. Fewer than 9,000 persons (0.3% of the total work force) were employed in agriculture during December 1974, and total gross revenues for 1973 were less than $137,000,000. By comparison, 1973 agricultural production was valued at $263,500,000 in San Bernardino County.

The number of unemployed in Los Angeles County was estimated at 244,500 in December 1974. This represented 8.1% of the total civilian labor force of 3,223,900. Los Angeles County is classified by the U. S. Department of Labor as an "area with substantial unemployment."

San Bernardino County--The economic base of San Bernardino County is oriented heavily toward manufacturing, agriculture, wholesale and retail trade, services, and government. Most industrial activities in the county (including agriculture) are located in the highly urbanized San Bernardino and Pomona valleys. These narrow valleys form the northeastern extension of the Los Angeles Basin; they contain approximately 80% of the county's population. Conversely, industrial activity in the Mojave Desert regions traversed by the proposed pipeline route is quite restricted. Transportation, government, and mineral extraction provide the major employment opportunities.

The leading employment sector in the San Bernardino Labor Market is government. In terms of total employment, the local, state, and federal government subsectors provided jobs for 85,400 workers (23.7% of the work force) in December 1974. Most of these workers were employed in state and local government (primarily public education). The major federal employers in San Bernardino County are Norton Air Force Base, east of San Bernardino, and George Air Force Base, east of Adelanto and northwest of Victorville.

Retail and wholesale trade sectors are the county's second largest employment group. In December 1974, 22.9% of the total work force was employed in trade-related activities. Retail trade accounted for 70,000 workers; wholesale trade provided 12,500 jobs. In 1972, retail sales by San Bernardino County's 5,855 retail trade establishments totaled $1,485,501,000, while 669 wholesale trade establishments recorded sales of $881,856,000. Retail and wholesale trade payrolls for 1972 were $184,279,000 and $157,610,000 respectively.

Service industries are ranked as the third largest employment group in the Riverside-San Bernardino-Ontario reporting area, providing jobs for an estimated 68,300 workers (18.9% of the work force) as of December 1974. In 1972, an estimated 4,541 service-oriented establishments in San Bernardino County recorded sales of $231,027,000; they had a payroll of $68,255,000. Government, retail and wholesale trade, and services are all categorized as nonbasic industries.

The leading basic industry employer in the San Bernardino labor market is manufacturing. In December 1974, nearly 55,000 workers were employed by manufacturers; they equaled 15.1% of the total work force. The 1971 Annual Survey of Manufacturers estimated the total value of industry shipments from San Bernardino County at $1,118,400,000, with a value added by manufacture of $649,000,000. The total payroll in manufacturing exceeded $284,000,000. Largest components within the manufacturing sector are primary metal processing and production and assembly of transportation equipment and supplies.

In terms of total dollar value earned, agriculture ranks as the second leading basic industry in San Bernardino County. During 1973, the total gross value of agriculture crops and products in the county was $263,450,100. A total of 22,800 persons was employed in agriculture in the Riverside-San Bernardino-Ontario employment reporting area during December 1974.

Other significant employment categories in the Riverside-San Bernardino-Ontario Labor Market include transportation, communications, and utilities; construction; and finance, insurance, and real estate. These sectors employed 5.2, 3.7, and 3.4%, respectively, of the December 1974 total labor force.

The combined valuation of residential and nonresidential construction in San Bernardino County was estimated at $234,700,000 in 1973. This was 3.8% less than the 1972 total building valuation, and it marked the first year since 1967 that construction revenues did not record an annual increase in the county.

The available labor force in the Riverside-San Bernardino-Ontario Labor Market was 502,700 in December 1974. A total of 48,200 persons were unemployed, giving a seasonally adjusted unemployment rate of 10%. The U. S. Department of Labor classifies the Riverside-San Bernardino-Ontario region as an "area of substantial unemployment."

Family Income and Retail Sales

Oxnard Plain Area--Comparative family income data for the state, the county and the two principal communities in the Oxnard Plain are tabulated below:

Family Income

	1959		1969	
	Median	Average	Median	Average
State of California	$6,726	n.a.	$10,732	$12,227
Ventura County	6,466	n.a.	11,158	12,054
Oxnard	6,471	n.a.	9,884	10,751
Port Hueneme	5,389	n.a.	8,360	9,332

n.a. = not available.
Source: Social and Economic Statistics Administration, 1967 and 1972.

During this 10-year period, significant increases in median incomes occurred, amounting to 59.6 percent for the state, 72.6 percent for the county, 52.7 percent for Oxnard, and 55.1 percent for Port Hueneme.

Comparisons of per capita income for 1969 follow:

State of California	$3,614
Ventura County	3,246
Oxnard	2,901
Port Hueneme	2,879

According to the annual report from the California Board of Equalization, taxable retail sales data for the state, county, and the two cities for 1973 were:

	Total	Per capita
California	$61,737,936,000	$2,977
Ventura	903,106,000	2,050
Oxnard	243,325,000	3,085
Port Hueneme	6,749,000	375[1]

[1] 1972 data.

Source: California Board of Equalization, 1974.

Santa Clarita Valley Area--No information on family incomes is available for this area of unincorporated communities. Also, data on taxable sales for this area are not collected and segregated by the State Board of Equalization. However, the vigor of the population growth and the expansion being recorded in business activities in the valley suggest that family incomes and taxable transactions per capita may average well above the state levels. In Los Angeles County, of which the valley is a small segment, the median family income in 1969 was $19,968. For the county, 1973 taxable transactions averaged about $2,650 per capita.

Personal Income and Retail Sales

Los Angeles County--Personal Income--Per capita personal income in Los Angeles County neared $6,000 in 1973. Total personal income in the county was estimated at $41,300,000,000 -- equal to one-third of the state total. During the five-year period 1969-1973, total personal income in Los Angeles increased 28.2%, while per capita income registered a 29.3% gain.

Retail Sales--Per capita taxable retail sales in Los Angeles County averaged $2,655 in 1973, $26 above the state per capita sales average. Total retail sales in Los Angeles County were $18,494,136, approximately 34% of the $54,442,388 in retail sales for all of California. Food stores lead in retail sales, followed by the automotive group, general merchandise stores, eating and drinking places, and gasoline stations.

San Bernardino County--Personal Income--Per capita personal income in San Bernardino County was $4,689 in 1973 -- slightly above the California average of $4,252 and considerably less than the Los Angeles County average of $5,928. Available personal income totaled $3,274,000,000. During the 5-year period between 1969 and 1973, total personal income in San Bernardino County grew by 54.4%, while per capita income increased by 49.3%.

Retail Sales--Per capita taxable sales in San Bernardino County are the lowest of the two counties. In 1973, per capita sales were $2,447, as compared with $2,655 for Los Angeles County, and $2,629 for California. Total taxable sales amounted to $1,708,554. Leading retail sales groups were food stores, the automotive group, general merchandise stores, eating and drinking places, and furniture, household goods, and appliances establishments.

Land Use

Ventura County

The county is roughly square, consisting of 1,884 square miles with 41 miles of shoreline. Boundaries are provided by Santa Barbara County to the west, Kern County to the north, Los Angeles County to the east, and the Pacific Ocean to the south and west.

In both a cultural and physical sense, Ventura County is divided into halves. The northern half is largely undeveloped and contains the Los Padres National Forest. Mountains in this area exceeding 8,000 feet in elevation are part of the Coast Ranges. Three major drainage systems, the Cuyama River and the Piru and Sespe Creeks, transect these mountains.

The majority of the population resides in the southern half of the county, which has become the focus of development activities. The southern mountains, part of the Transverse Ranges, rarely exceed 3,000 feet. Extensive valley lands found along the Ventura River, Santa Clara River, and Calleguas Creek, and in the lowlands of the coastal plain accommodate the urban and agricultural activities. All of the county's nine incorporated cities are found here. Because of the excellent agricultural land, the county led the nation in the production of lemons in 1969 and ranked second in avocado, spinach, and chili pepper production.

Agriculture is the major land use in the Oxnard Plain. Most of the land between the Pacific Missile Range northwest of Mugu Point and the urban complex of Port Hueneme-Oxnard is used for agriculture. Except for a strip of recreational land adjacent to the coast, agricultural lands extend north from Port Hueneme-Oxnard to the Santa Clara River. The area between State Route 1 and the Santa Clara River is largely agricultural, but includes the deactivated Oxnard Air Force Base and urban developments along the highway, e.g., Camarillo, El Rio, Nyeland Acres, Camarillo Hills, and East Oxnard. North of the Santa Clara River, there are extensive agricultural areas between Saticoy and Santa Paula.

Other land uses in the Oxnard Plain include the Ventura Marina and Olivas Park Golf Course along the Santa Clara River floodplain near the coast, the Saticoy Country Club near South Mountain, large duck ponds northwest of the Pacific Missile Range, sand and gravel mining along the Santa Clara River floodplain, and the percolation basin on State Route 118 southeast of Saticoy. There are also some oil wells and storage tanks located on agricultural land between Routes 1 and 101.

Transportation facilities present in the Oxnard Plain include roads and highways, airline service, railroad service, bus service, and ship facilities. Direct air service is available to Los Angeles and Santa Barbara from the Ventura County Airport. Commuter carrier service is provided by Golden West Airlines. The Oxnard Municipal Transit Line offers bus service to the Cities of Oxnard and Port Hueneme, and to Ventura College in the City of Ventura. Ventura County Railway Company provides a freight service in the Oxnard-Port Hueneme area. The railroad operates on a six-day work week, 8 hours per day. The company has an interchange track with Southern Pacific Railroad which runs along Fifth Street in Oxnard.

Port Hueneme Harbor (Oxnard Harbor District) has six concrete wharfs with ten 36-foot-deep (mean lower low water) berths and two wharfs with six 13- to 14-foot-deep berths.

Los Angeles County

Los Angeles County consists of 4069 square miles with approximately 65 miles of shoreline. Bordering counties include Ventura to the northwest, Kern to the north, San Bernardino to the east, and Orange to the southeast. The Pacific Ocean forms the western boundary and has historically provided a major attraction for population concentration and urbanization.

The San Gabriel Mountains extend along the eastern border and basically bisect the county on an east-west axis. The major population concentration occurs in the southwestern quadrant with the Cities of Los Angeles and Long Beach containing a significant portion of the county's roughly seven million inhabitants. Other prominent geographical features include the Santa Monica Mountains to the northwest of the City of Los Angeles, the Santa Clara, Los Angeles, and San Gabriel Rivers, and a portion of the Mojave Desert located in the northeastern sector. Agriculture has historically been a major land usage with over 550,000 acres devoted to that use in 1970.

San Bernardino County

In San Bernardino County the land ownership along the right-of-way is about 51 percent Federal and 49 percent private. There is some mineral extraction. There is no land used for agriculture or commercial forest; the greatest use is for recreation.

Major sections of the pipeline corridor are widely used for recreation, especially the Mojave Desert. The activities include camping, biking, rock collecting, hunting, and the use of off-road vehicles.

The area's potential for future development appears to center on an increase in recreational activity. This would seem to be self-limiting in some respects, since much of the attraction of the area lies in its vast stretches of uninhabited landscape. As the number of recreation seekers increases, this aspect of the area's attraction is likely to decrease.

Future development will probably occur at sites of mineral discoveries. However, the areas involved in such pursuits are usually small, with the exception of open-pit mines.

Paleontological, Archaeological and Historical Resources

Three separate historical periods can be defined for the Ventura Basin. There is also a longer period of pre-history, part of which can be defined. Following the Pre-Historic Period there is the Indian Period, then the Spanish-Mexican Period, ending in the present American Period.

Pre-Historic Period

Although much of the evidence regarding the beginning of the pre-historic human occupation in southern California is tenuous, a general statement can be made.

Recent technological advances in dating techniques (i.e., radiocarbon 14 and the newest amino acid analysis) indicate a far greater time period for man in southern California than has been previously believed. Where previously extrapolated dates of 20,000 to 30,000 years were only partially accepted by archeological authorities, recent dates on human material indicate the possibility of human occupation as early as 50,000 years ago.

As a result of these discoveries, no topographically acceptable environment in southern California can be rejected as a site of human occupation. It is, therefore, true that even in those areas where reasonably extensive archeological investigations have taken place, careful re-examination may very well prove to be necessary.

Indian Period

The Hokan linguistic group occupied the entire coastal area of the Ventura Basin. They are part of a large family in southern California which includes the Salinan, Esselen, and the Yuman. The Chumash group, in turn, is divided into a series of tribelets, among which is the Ventureno. The Ventureno were principally marine-oriented in the sense of food supply. Inland from the coast, there was a greater reliance on hunting and gathering. Agriculture was unknown to these people in the formal sense of farming as practiced by Europeans.

The most outstanding feature of Chumash culture was their great skill at boat building. Carefully designed plank canoes sealed with tar obtained from natural oil seepages gave the Chumash a small monopoly on coastal trade. They were also accomplished fishermen.

Following the proposed pipeline route out of the Oxnard Plain and passing along the Santa Clara River and the Calleguas Creek drainage, the corridor passes the border between the Chumash and the Shoshonean family groups, about halfway between Sespe Creek and Piru Creek on the Santa Clara River. From this point on, the southern boundary of the Shoshonean-speaking Alliklik runs along the northern slopes of the Santa Susana Mountains, and into the Santa Clarita Valley.

This area of the pipeline route was used on a temporary basis, with the possible exception of the extreme western and eastern portions near La Vista station and near the Quigley Canyon station, by the inland Chumash peoples and the Alliklik. The area includes both foothill and mountainous terrain. According to season, the groups moved to camps in the foothills to harvest natural plant crops and hunt.

Small hunting parties, as well as individual hunters, probably ranged into the most remote areas. However, by and large, all camps were located in the larger canyons situated near a good, dependable water supply. These community-based and wandering groups would have established sites where occupancy may have ranged from a few days to several months during the course of the year.

Spanish-Mexican Period

The first European to contact the peoples of the Oxnard Plain was Juan Rodriquez Cabrillo. In October of 1542, Cabrillo, sailing under the order of Mendoza, the Viceroy of New Spain, anchored his vessel off Mugu Lagoon. Although he stayed but a short while, he was greatly impressed by the Ventureno's boat building skills. Cabrillo was sufficiently impressed by the number of boats that put out to greet him that he named their settlement Pueblo de las Canoas (Village of the Canoes) (Moriarty and Keistman, 1963).

The Shoshonean Alliklik were not discovered by Europeans until the expedition led by Gaspar de Portola passed down the Santa Clara River to the ocean in August of 1769.

Portola, acting under orders from the Visitor General of New Spain, was seeking to explore by land the coast of California and to establish a fort at Monterey. He was also to look for additional presidio (fort) sites on usable harbors and to select favorable localities where missions could be established. Portola's route became the El Camino Real along which Father Junipero Serra later established the famous California missions.

On March 31, 1782, Father Serra officially dedicated the Mission San Buenaventura which is located at the mouth of the Ventura River, about 13 miles northwest of the pipeline route. Mission San Buenaventura served the Chumash peoples as a center for conversion to Christianity and education as Spanish subjects. By royal decree, enormous areas of land were granted to the mission, including most of the Ventura Basin.

By 1822, as a result of a successful revolution in Mexico which resulted in the establishment of the Mexican Republic, the new governors of Alta California proceeded with their program of secularizing the missions. Spanish control being eliminated, the Mexican government declared that all missions must be secularized. This order was published in 1834. Two years later, in 1836, the church-owned lands belonging to the Mission San Buenaventura were taken away and given to private owners.

American Period

With the signing of the Treaty of Guadalupe Hidalgo in 1848, the entire area of the pipeline route, along with other California territories, became part of the United States of America.

By 1850, when California was admitted to the Union as a state, the Ventura Basin was still principally a cattle grazing area. During the great migration of Americans into the gold mining area, the cattle business prospered. This was followed in the late 1850's by a long drought which practically destroyed cattle raising as a business in California.

The subsequent loss of revenue resulted in the final break-up of the remaining great cattle ranches, and, consequently, the outcome was the creation of large agricultural projects. This began slowly at first, but was expanded quickly after the arrival of the Southern Pacific Railroad. Combined with an already well-developed marine transportation facility, the railroad offered an even greater outlet for California agricultural products, and within a few decades the state had become a major agricultural producer in the United States.

From the turn of the century until the present, the arable portions of the area under consideration have remained rural. In addition, technological advances have allowed for increase in the production of natural resources, most particularly petroleum. From 1950 to the present, increasing urban pressure from Los Angeles County has been slowly changing the region from a rural setting to a low density urban environment.

The proposed route will cross both Highway 1 and Highway 101 (El Camino Real) (MP 8.2). In the Santa Clarita Valley area, the pipeline will pass approximately 1.2 mile to the north of the Pico No. 4 site (the first commercially producing oil well in the United States) in the Santa Susana Mountains.

Archaeology

This section considers the proposed pipeline route in four reaches: the first, the Oxnard Plain from the coast to near La Vista Station (MP 12); the second, La Vista Station to Quigley Canyon Station (MP 53), the third, Quigley Canyon Station to Palmdale; and the fourth, Palmdale to Hinkley.

Coast to La Vista Station (Reach I)--Numerous archeological sites have been discovered in the Oxnard Plain. This suggests that the region was generally occupied by aboriginal populations and there may be yet undiscovered sites along the pipeline route.

La Vista Station to Quigley Station (Reach II)--For the most part, the pipeline route through Reach II has not been systematically surveyed for archeological sites. Several environmental assessments have been made in the Saugus-Newhall area. These environmental reports are on file at the University of California at Northridge.

These assessments, along with general information collected by archaeologists who have been in the area, tend to bear out the previous statements about land-use practices. Large temporary sites are reported in the area and are generally located in canyons near good sources of water. In the less desirable terrain, small hunting and food collecting and preparation camps are located near springs, rock shelters, or caves. Most of these sites are shallow and small in size.

The situation changes in the river courses and valleys adjacent to the pipeline route. Many of these areas have been occupied for thousands of years. There is little doubt that as the populations increased over long periods of time, ever-increasing areas in the surrounding foothills and mountains were systematically used for hunting and gathering.

Since population density was greater toward the southern and western end of Reach II, it must be concluded that this is the area that was most utilized for human occupation at the period of European contact. As a consequence, there may be more archeological sites that were occupied for longer periods of time along this portion of the pipeline route.

A review of the records from the University of California at Los Angeles Archaeological Survey discloses that the following data are recorded for Reach II. Starting with four archeological sites, it should be emphasized that these are all in the vicinity of Saticoy. These sites are all on the north bank of the Santa Clara River and undoubtedly represent several thousand years of village occupation. There are no sites recorded in the South Mountain area. In addition, there are no sites located along Oak Ridge south of Fillmore. It should be noted, however, that Grimes Canyon was a well-known source of lithic material or the manufacture of small stone tools. Lithic material taken from this area was traded widely through the Chumash group. Therefore, there is a good possibility that quarry sites and the related villages or occupation areas can still be found in this vicinity.

Two sites have been recorded in the Happy Camp Canyon area. One of these is a series of quarry locations for "Grimes Canyon Fused Shale" and the other is a large living area.

From the Los Angeles County line east, there are no sites recorded in the hills within the project area. A brief recorded reconnaissance made 8 miles to the south of the proposed corridor showed only one limited-use site. ("An Archaeological Reconnaissance of the Oat Mountain Vicinity").

No archeological sites are recorded along the Santa Clara River Valley within the proposed pipeline corridor. However, the Portola expedition in 1769 recorded an Indian village, probably called Kashtuk, near the confluence of Castaic Creek and the Santa Clara River.

A final consideration is the likelihood of buried archeological deposits. A number of instances of such deposits buried under several feet of Halocene alluvium have been reported for this region.

A review of archeological records for the Ventura Basin indicates that the proposed corridor should not disturb any recorded archeological sites.

There is no information available on historic or archeological sites in the immediate vicinity of the remaining two reaches. Information for the general vicinity of the route indicates no recorded sites.

Archaeologists have estimated an overall archeological site density from 0.25 site per square mile to 10 sites per square mile in the California desert. Very few of these sites, however, have been inventoried. It is generally accepted by professional archaeologists working in the California desert that less than 10 percent of the total sites in the area have been discovered. Numerous springs and intermittent streams occur near the proposed pipeline route which have not been surveyed by archaeologists. It is likely that evidence of aboriginal activity will be found around these bodies of water. Generally, where water is available in the desert, aboriginal populations have probably used it.

Recreational and Esthetic Resources

Major recreational facilities located in the area of the proposed LNG plant site are the following: Parks (state, county, and city); marinas (public); deepsea sport fishing landings; piers (public); and golf courses (public, private, and government).

The 2 most significant recreational facilities within the vicinity of the proposed LNG facilities are Channel Islands Harbor and Hueneme City Beach Park.

Channel Islands Harbor

Channel Islands Harbor is a recreational boating marina located approximately 2 miles northwest of the Port of Hueneme. It is under the administration of the County of Ventura. The harbor opened officially in 1965 and currently has 1,035 boat slips available. Expansion by 500 additional slips is underway. At present, 935 boats are in slips, and 208 boats are in dry storage.

Hueneme City Beach Park

The city operates Hueneme Beach Park along the coast. This park consists of about 50 acres and covers 90% of the usable beach area within the city. Along with numerous items of recreational equipment, the park contains 2 restroom buildings, a public fishing pier, and parking for 375 cars. Summer weekday usage is approximately 3,000 persons per day, while weekends normally draw 5,000 persons per day. Holiday usage approaches 12,000 persons per day.

In the vicinity of the pipeline route major recreational land-use areas include:

Area	Location
Los Angeles National Forest	Both north and south of the pipeline
Joshua Tree State Park	25 miles NE of Palmdale
San Bernardino National Forest	40 miles south of Adelanto

Scenic/Aesthetic Values

The LNG plant site is part of a relatively flat plain gently sloping toward the ocean. The land surrounding the property has been zoned M-2 for heavy industrial use. Surrounding land uses, where development has taken place, are consistent with this zoning. Several industrial plants are located in the immediate vicinity of the proposed LNG plant site.

The general area of the site is traversed by numerous roads, some unimproved, and the Ventura County Railway. The Ormond Beach Generating Station is directly to the southeast of the site. The electrical transmission lines and towers are also visible from any point on the site.

Exposure

Being on a relatively flat plain, the property is not easily visible from the surrounding communities. However, it is visible from the foothills surrounding the Oxnard Plain, which are from 6 to 15 miles away.

The plant site is visible from Hueneme Road on the north, Perkins Road on the west, and Arcturus Avenue on the east. It can also be seen from the Ormond Beach Generating Station and from the sand dunes along Ormond Beach. The residential condominium developments within the city of Port Hueneme along Surfside Drive are 2 miles from the site. Second floor windows facing east and southeast have a view of the site.

Summary

The scenic value of the site, as it currently exists, is considered small. The exposure of the property, because of the flat plain upon which it is located, is also small. These factors, combined with the industrial developments in the immediate vicinity, make the LNG plant site one of low visual aesthetic value.

The pipeline route passes through a series of scenic valleys and canyons as it progresses to Quigley Canyon Station and on to Palmdale. However, most of the route proceeds through an intensively developed corridor that lies between two segments of the Los Angeles National Forest. The pipeline alignment follows an existing right-of-way that remains in the bottom of canyon drainages whenever possible to minimize visual impact.

Panoramic views of Oxnard and the coastline are provided from the pipeline route as it rises to the top of Oak Ridge. Another scenic view is provided from the pass at Sierra Pelona, where portions of Antelope Valley and the Mojave Desert are visible. These areas would be classified as having high visual qualities.

The proposed pipeline passes thorugh the western Mojave Desert -- a geologically old valley. Considerable burden from the uplifted Tehachapi Mountains to the north and San Bernardino/San Gabriel Mountains to the south and west has resulted in the formation of a series of coalescing alluvial fans. These fans slope gently downward toward the center of the basin. Playa lakebeds are found at the lowest points.

The resulting topography over most of this geographic landscape is relatively flat and uniform. Local landforms are not an important visual component, except in those areas where isolated buttes and hills of tectonic origin rise several hundred feet above the basin floor. Because these former mountain peaks are the only evidence of topographic relief within the basin, they become focal points of viewer attention. In most other areas, the highly eroded Tehachapi Mountains (to the north), the San Gabriel Mountains to the west, and San Bernardino Mountains (to the south) dominate viewer attention with their strong lines and forms.

Vegetative patterns are important in this geographic landscape. Where extensive Joshua tree communities occur, there is considerable variety in form, line, texture, and color. The unusual linear forms of these 10 to 20 foot tall trees are highly visible, resulting in substantial variation in line and shape. However, in areas where Joshua trees are not widespread, the characteristic low-lying scrub vegetation of the Mojave Desert fails to break the uniformity of the scene. In these instances, viewer attention will normally focus on the distant Tehachapi, San Bernardino, and San Gabriel Mountains, where chaparral and junipers add texture and color to the background landscape.

In general, color is not a significant visual element in this landscape. Most color is provided by the somber brownish-green hues of vegetation or the tans and browns of differing soil types. Color becomes an important element only during certain times of the day (e.g., near sunrise or sunset) or following rainstorms in the late winter and early spring. During the latter period, perennials and annuals temporarily transform the desert with bright colors.

There are no scenic vista points providing panoramic views in the Mojave Desert geographic landscape.

Because of the uniformity of topography and lack of substantial variety in vegetation and other important visual features, the Mojave Desert sector of the pipeline route has been categorized as having low to medium "visual quality."

Air Quality

In the summertime, Ventura County experiences an air flow that is dominated by sea breeze. During the daylight and evening hours, the air moves across the coastal plain and through the major valleys to the interior. At night, the wind reverses direction, blowing down the valleys to the coast. If this flow is strong, it will generally provide a large enough air volume under the inversion layer to keep pollutant concentrations low. This inversion layer is almost constantly present during the summer and early fall. When meteorological conditions do not break up the inversion layer, and a weak sea breeze exists, accumulations of pollutants occur.

Prevailing sea breezes act to move the air into the eastern parts of the air basin where contaminant concentrations tend to be higher. A reversal of these prevailing breezes, caused by a Santa Ana easterly wind, flushes the air in the Los Angeles Basin out to sea. When this wind ceases, the resumption of the sea breeze sometimes moves the pollution-laden air into Ventura County, causing high accumulations of pollutants in the county. Also, when the pollution level is high in the Los Angeles basin, pollutants cross over the hills and reach Ventura County.

The local conditions in Ventura County act to generate air quality problems supplementary to the influences of the rest of the South Coast Air Basin. A 1970 emission inventory, conducted jointly by the Ventura County Air Pollution Control District and the U.S. Environmental Protection Agency, established that automobiles were responsible for 46 percent of the total hydrocarbons, 81 percent of the reactive hydrocarbons, 7 percent of the particulate matter, 56 percent of the oxides of nitrogen (NO_x), 92 percent of the carbon monoxide (CO), and 11 percent of the sulfur dioxide (SO_2) emitted into the Ventura County atmosphere. Other transportation sources of pollution include aircraft, ships, and railroads. Stationary sources of pollution include petroleum production, use of solvents, incineration, industrial fuel combustion, and agricultural uses.

Air pollution concentrations have been measured in Ventura County since 1965, when the California State Department of Public Health conducted a 1-year study of the pollution problems there. They set up oxidant monitoring stations in Ojai, Ventura, Oxnard, Santa Paula, and Thousand Oaks. During the period May 1965 through April 1966, oxidant concentrations regularly exceeded the present Federal air quality standard (0.08 ppm hourly average) at every station. In terms of the number of days measured having one or more hours above the oxidant standard, Ventura had 26 percent, Oxnard 30 percent, Ojai 46 percent, Thousand Oaks 50 percent, and Santa Paula 52 percent.

Since that study was completed, the Ventura County Air Pollution Control District has set up monitoring stations in Ventura, Camarillo, Ojai, Santa Paula, Simi, Port Hueneme, Point Mugu and Thousand Oaks.

The air quality in the upper regions of the pipeline project is influenced greatly by wind and weather systems from the San Joaquin Valley, the San Fernando Valley, and the Mojave Desert.

Pollutant concentrations are generally much higher in the Santa Clarita Valley than in the coastal regions due to (1) spillover of pollutants from the Los Angeles Air Basin and (2) the stronger coastal winds which disperse contaminants more rapidly than occurs in the inland areas.

Environmental Noise

The existing noise environment within a 2-mile radius of the proposed route is influenced by:

- the generally flat topography
- the predominance of residential land usage north of Hueneme Road
- the proximity of Point Mugu Naval Air Station
- the location of several industrial facilities near the proposed vaporization facility site
- the Southern California Edison Ormond Beach Power Plant

Their results show daytime L50 noise levels between 45 and 60 dBA, with the nighttime levels being about 10 dBA lower.

Impact Analysis

Summary of Major Impacts

Climate

The proposed project should have insignificant impact upon the climate.

Topography, Geology, and Soils

The higher elevations--foothills and steeper mountainous areas--will require modifications to the topography as a result of pipeline construction. These modifications are not extensive and should not have a major long-term effect upon the environment.

Water Resources

The proposed project would receive up to 475,000 gpm of heated water, via pipeline, from the discharge system of the Ormond Beach Generating Station. The temperature of the heated water would be depressed by about 15°F and returned to the existing outfall line. Since this water has already been treated, additional chemicals would not be needed. The net result would be fewer chemicals added and heating induced by another facility reduced by the proposed facility.

Vegetation, Wildlife and Ecological Considerations

Two endangered species of wildlife could be adversely affected by the proposed project. The Brown pelican nests on Anacapa Island which is directly offshore from the proposed LNG terminal. In addition the California Condor occurs in the Sespi Condor Sanctuary. The proposed pipeline would pass within four miles of the Sanctuary. Increased activity could further harass these two endangered species.

Economic and Social Factors

The payroll for the 39 months of construction of the proposed project would total some $35 million. Ninety percent of this amount would go to the Ventura county area and be injected primarily into the local economy. During June of 1974, some 5,300 persons were engaged in contract construction in Ventura County. The proposed project would employ some 1,900 persons during peak operations. It is estimated that 90 percent of the employees would come from Ventura County. As a result the local economy would benefit but would not be burdened with providing additional support services.

Land Use

The use of small areas of land and water would be modified; however the changes would be small and only incremental in nature. There should be an insignificant impact upon the environment as a result of the proposed project.

Paleontological, Archaeological, Historical, Recreational and Aesthetic Resources

The proposed project should not significantly affect these resources.

Ambient Air Quality

The proposed vaporization plant would emit some nitrogen dioxide and sulfur dioxide. The air quality in the Ventura Oxnard area is already somewhat degraded, but meets state and federal standards for NO_2 emissions. Emission in the immediate vicinity of the plant could exceed state-Federal standards for NO_2 emissions about once each year.

Environmental Noise

The proposed project would increase the noise level in the vicinity of the proposed vaporization plant some 10 dBA (20%) above ambient. This increment is not expected to have a significant impact upon the environment.

Detailed Analysis

Climate

Analysis of both construction and operational phases of this proposal revealed no climatic impacts of significance except those directly related to our quality. These are treated under the subheading Impacts on Ambient Air Quality later in this section.

Topography, Geology and Soils - LNG Terminal

Construction of the proposed LNG vaporization and storage facilities will result in minimal terrain modification on the site. In addition to very minor grading, an excavation will be required for installation of each of the 4 LNG tanks and concrete dikes. Excess soil will be used to raise the grade of access roads and the plant-site area. The amount of excavated material is not yet known.

Construction of the proposed facilities will affect the soils in the area only to the extent that they will be relocated during grading and excavating.

No subsidence or significant settlement should occur due to construction of the proposed facilities. No over-steepened slopes or any other potentially unsafe condition will be created as a result of construction operations.

Construction of the proposed facilities will not deplete any existing mineral resources or require the development of new sources of construction materials. All materials will come from existing sources which have stockpiles and reserves well beyond the requirements of this project.

Construction of the proposed project facilities will not affect the physiography, geology, or seismicity of the Oxnard Plain.

There will be no significant effects on the topography, geology, or soils from construction or operation of the LNG Terminal and plant.

Topography, Geology and Soils - Pipeline

Erosion--Excavation and the passage of construction equipment will disrupt vegetation and reduce the natural stability of near-surface materials. As a result, the area along the proposed route will be more susceptible to erosion. In the flatter areas traversed by the proposed route, the impact will be minimal. In those portions of the alignment crossing steeper terrain, erosion can be expected to be more severe during and immediately after construction until revegetation occurs.

Differential Settling--Along the first 8 miles of the pipeline route, the water table is sufficiently close to the ground surface that dewatering of the pipeline trenches may be required. Dewatering can cause localized settling or subsidence of ground surfaces if the water table is drawn too deeply for an excessive period of time. This is not expected to be a problem in the proposed project. The depth of the pipeline trench in such areas will range from 6 to 9 feet and require lowering the water table no more than 5 to 7 feet for a minimal period (1 to 2 weeks) at any one point along the pipeline route. The dewatering requirements for construction of this pipeline are such that the impact from differential settling will be minimal and confined within the pipeline right-of-way.

Alteration of Slope Stability--In the hilly and mountainous areas of the alignment, excavation during construction for the proposed pipeline and/or access roads may result in locally reducing slope stability, creating an increased localized potential for landslides.

Water Resources

On-shore--During construction in the relatively flat plain and valley portions of the pipeline route, no erosion problems are anticipated; consequently, no impact on water quality in streams will occur.

In the higher elevations of the foothills and the steeper mountainous areas, the soils become somewhat more erodible. It is anticipated during the winter months, when streams are flowing, some sedimentation will occur in the Santa Clara River and its feeder streams due to erosion of the soils disturbed by construction of the pipeline. Erosion will decrease in time as the right-of-way is revegetated, except for areas where soils and vegetation are disrupted due to maintenance traffic.

The water table in the Oxnard Plain is often within a few feet of the surface and dewatering of the trench along this section of the pipeline may be required (groundwater levels in the trenches are not expected to be affected by tidal actions). Removal of groundwater from the trenches will be accomplished by pumping. Since this groundwater is of that quality normally discharged to the environment from agricultural drainage, no adverse impact from the operation is expected. However, a testing program is planned to identify chemical characteristics of groundwater and hydraulic properties of water-bearing materials. Data collected in this program will be used to predict dewatering effects and the necessity of treating the discharged water.

The locations of discharges into the ocean have not been determined, but two possibilities would be to discharge directly into the ocean through lines laid across, or buried beneath the beach; or to discharge into the Oxnard Industrial Drain to the west of the site, and from there into the ocean. This water has a lower salinity than is found in the ocean, so there will be a short-term decrease in salinity of the ocean water near the point of discharge. This discharge will not be unprecedented because the water which ordinarily flows into the ocean from the industrial drain is primarily of low salinity. Any groundwater discharges resulting from dewatering operations will meet the requirements to be specified by the California Regional Water Quality Control Board prior to discharge.

The quantities and rates of runoff during construction will be controlled to prevent any adverse impacts. Hydrostatic test waters will be discharged either in catchments along the right-of-way or into natural drainage areas. Discharge will be controlled to minimize erosion.

Approximately 11.5 million gallons of fresh water will be utilized for hydrostaic testing of each LNG storage tank. If scheduling permits, the same water will be used for testing each of the tanks. Discharge of these waters will have an insignificant effect on the marine environment, because the volume to be used is roughly equivalent to the flow from the "J" Street drain alone during a period of only 2 to 3 hours during a moderate storm. Accidental spillages of petroleum products or other materials, such as crankcase lubricants or solvents, will be of such small magnitude that their effect on the environment will be negligible.

Chemical toilets will provide sanitary facilities during construction and this will not impact any local water resources. During plant operation sanitary discharges will be diverted to the Oxnard sewer system. Fresh water for domestic use will be obtained from the local municipal water system.

There will be no solid wastes or by-products generated from operation of the pipelines. As there are no sanitary facilities planned at the metering station nor anywhere along the proposed pipeline, there will be no sanitary wastes requiring disposal.

Water for construction will be obtained from the municipal water distribution system rather than from local wells.

The fresh water aquifers of the Oxnard Plain could possibly be contaminated as a result of construction activities where the alignment traverses aquifer recharge areas. The possibility of contamination to measurable levels is considered extremely remote.

Marine--Effects of the proposed project on the physical marine environment will result from the marine facility construction, and from discharges of groundwater and hydrostatic test water into the sea. This section addresses the probable influence of construction and operation of the proposed facilities on oceanography and water quality.

Physical Changes--Construction of the "T"-head pier will involve driving piles into the existing sea bottom. The effect of this installation will consist of a short-term local increase in turbidity due to resuspension of sediments. These sediments are most likely unpolluted, according to applicable EPA (1973) dredge spoil disposal criteria; however, this will be established by a program of sampling and testing prior to construction. No dredging is required for the proposed facilities.

The construction of the facilities is expected to have little significant effect on the oceanographic conditions in the area. The final design of the pier will incorporate criteria for the spacing of the pile supports, which will minimize the effect on the littoral sediment transport of the area.

Thermal Changes--Base load vaporization will occur in seawater-heated vaporizers, which will utilize 450,000 gallons per minute (GPM) of seawater during normal operations. The seawater will be obtained from the discharge system of the Ormond Beach Generating Station. The water will be transferred by pipeline to the LNG vaporization plant, where it will be used as a heat source for vaporization. The 2 generating units at the station will supply up to 475,000 gpm of warmed seawater.

In the vaporizers, the warmed seawater temperature will be depressed by about 15°F and returned to the existing outfall line. In the event of a shutdown of the Generating Station, gas-fired seawater heaters will be used to warm the seawater so that a below-ambient discharge will not occur.

The Ormond Beach Generating Station intake and outfall structures will be utilized as they now exist. The outfall is 1,350 feet offshore at a water depth of 32 feet mean lower low water (MLLW). The discharge outlet extends vertically upward from this point to a water depth of 15 feet MLLW, where the effluent is jetted upward. Because the discharge temperature will always be less than it is at present, but will never be lower than ambient, the impact of this combined discharge on ambient temperatures should not be significantly different than it is at present.

The seawater used for vaporization will be exposed to the atmosphere and thus aerated prior to discharge. The discharged seawater will be rapidly mixed with the ambient seawater, which is normally near saturation or is supersaturated with dissolved oxygen. Thus there should be no oxygen demand on receiving waters because of the LNG plant discharge.

Seawater will be required to remove the latent heat content of the exhaust steam in the LNG ships' condensers. Preliminary calculations indicate that for the 165,000-cubic-meter ships, about 60,000 gpm of seawater at 6°F above ambient will be discharged while ships are underway. While at the "T"-head, the same volume of water will be discharged, but it will be only 2°F above ambient. The lesser temperature rise while ships are berthed is due to the reduced power requirements of the ships. The effects of this discharge do not appear to be significant; however, a complete evaluation will be made when ship design specifications are finalized.

Chemical Changes--No biocide treatment of the seawater system will be required because the LNG vaporization facility will take advantage of the anti-fouling treatment presently in use at the Ormond Beach Generating Station. No significant impacts are anticipated, although this should be reevaluated after design requirements are finalized.

1. Sanitary Wastes. The LNG facility will produce approximately 4,500 gallons per day of sewage when in full operation. This sewage will be disposed of through the Oxnard municipal sewer system. The additional sewage load will represent an insignificant increase in wastes discharged into the system.

Sanitary and other liquid wastes from LNG ships will be processed onboard. No wastes will be discharged from the ships while they are in the terminal.

2. Industrial Wastes. The only industrial waste to be discharged to the marine environment from the facility will be about 70 gpm of pH 5.5 water derived from the gas-fired vaporizers periodically used for peaking. These vaporizers will be used for up to an estimated 480 hours per year under normal operating conditions. The water will be diluted by mixing with the 450,000 gpm base load waters and discharged to the ocean through the existing outfall. This discharge should have a negligible impact on ocean water quality.

The first 2 effects cited were based upon observations made in enclosed water areas with little wind, wave and current circulation; or during extremely large crude oil spills. Since the project site is located on an open coast with considerable wind, wave and current action, these adverse effects are not likely to occur.

In addition, small discharges of materials incidental to construction and maintenance operations, such as paint, solvents, and lubricating oils, will undoubtedly occur. Because of the very small quantities used and the infrequency of the spills, however, such incidents are not expected to significantly affect the quality of the marine waters near the proposed site.

Spills of Hazardous Materials--There will be an LNG containment system under the unloading facilities; however, should there be a spill, its impact on the marine water quality is expected to be small to negligible. Dispersion of LNG into the water column is expected to be slight. Since the density of LNG (approximately 26 lbs/ft^3) is low compared to water, buoyant forces will tend to prevent mixing into subsurface waters. Furthermore, the small droplets of LNG which are most likely to enter the water column will be vaporized rapidly into much larger and lighter bubbles of natural gas which will easily move upward to the surface.

Of potentially far greater impact on the physiochemical properties of the seawater than an LNG spill is the possible effect of a fuel oil spill. Bunker C fuel oil and diesel oil will be transferred to tanks at the facility for subsequent plant use or bunkering of the LNG ships. Bunker C fuel oil will be delivered to ships as needed from a 132,000-barrel land based tank. The Bunker C requirement is not known and will depend upon requirements of the ships using the terminal. Diesel oil for emergency plant use will be stored in a 5,000-barrel tank.

Studies have shown that the more refined a petroleum product is, the more detrimental its effect will be on water quality and marine biota.

Expected physical and water quality effects associated with a fuel oil spill are the reduction of sunlight into marine waters (not likely to occur with a diesel oil spill) which is necessary for phytoplankton photosynthesis, and the reduction of the dissolved oxygen content beneath an oil slick. Also, the lighter fractions of petroleum compounds may go into solution in the water column. Some of these lighter hydrocarbons are toxic to marine life.

Vegetation

The major impacts on vegetation will occur during construction of the proposed pipeline and could be apparent for some time after construction, depending on the vegetation type affected. Coastal sage shrub/chaparral and agricultural land comprise approximately 43 and 31 percent, respectively, of the vegetation directly impacted. Grassland, oak woodland, and riparian vegetation types, respectively, comprise about 17, 6, and 3 percent.

The major impact of construction will probably be the visual impact of the cleared right-of-way through the various plant associations. This visual effect will vary with each vegetation type and the revegetation time involved. The biological impact is described below.

The loss of protective vegetative cover will result in the elimination of the root systems and aerial parts of plants. The loss of these parts, which retard runoff, hold the soil, and to some extent control the release of water to the environment, may accelerate erosion, especially on steep slopes and other naturally unstable areas. The loss of animal habitat due to vegetation removal will be minimal except for those animals that have small home ranges and/or are restricted to the pipeline right-of-way.

Clearing the vegetation will also temporarily disrupt primary biological productivity, which forms the base of terrestrial food chains. Therefore, the food materials available to some herbivorous animals, such as small rodents, will be slightly decreased, and the amount of food available to predators will be correspondingly decreased. However, such impact will be minimal due to the estimated low number of individuals of a small number of species that may be influenced.

The impact on native vegetation may be apparent for up to and exceeding 20 years (particularly in woodland areas), while agricultural lands may return to their preconstruction state following the first crop planting. Some orchard crops, however, may take 10 years or longer to return to preconstruction productivity.

Impact on areas adjacent to the right-of-way will be directly influenced by the construction techniques employed, by the construction personnel, the season of construction, the type of vegetation, and the nature of the substrate. Susceptibility of the vegetation to fire during the dry summer and fall seasons necessitates that equipment have spark arrestors and construction crews observe fire prevention rules.

If uncontrolled, the release of hydrostatic test water could cause erosion and disturb vegetation along and adjacent to the pipeline route.

The quality and agricultural productivity of cultivated lands along the narrow trenched zones is expected to diminish due to minor loss of topsoil and its mixture with the less productive subsoil. This is expected to be of small magnitude and significance.

Lands devoted to tilled crops or to fruit- or nut-bearing trees will be disrupted but such damage is considered mitigable through negotiation. However, those lands which support natural vegetation can, in most cases, only be protected from the elements by a planted crop which approximates the natural first successional stage. Restoring the pre-project plant community must be left to natural successional processes. Thus, disturbing the soil, in effect, replaces advanced successional stages with early-stage types and evokes a concomitant shift in animal species composition. While pipeline construction is certainly not a natural phenomenon, it is comparable to other processes to which the resident plants and annuals are adapted to adjust. Change will be of greatest significance in those vegetation associations which are the farthest advanced successionally and therefore require the longest period of recovery.

Wildlife

As noted elsewhere, serious disruptions of existing ecosystems are not expected to occur in connection with pipeline construction. This of course assumes that reasonable care is exercised in design and installation and that careful attention is given to restoring vegetative cover to disturbed soil surfaces. These measures are not adequate where species are involved whose populations are in jeopardy.

Directly offshore from the proposed terminal site at Oxnard is Anacapa Island, a part of the Channel Islands National Monument. Anacapa supports a nesting colony of the endangered brown pelican which has undergone serious declines in recent years due primarily to pesticide-induced nesting failures. The placement of unloading facilities and the activities of tankers and other associated vessels could precipitate further decline of this species through pollution and disturbance. That the species is vulnerable to disturbance is demonstrated by certain Mexican colonies which are considered to be in jeopardy due to harassment by tourists.

The proposed pipeline will approach within four miles of the south boundary of the Sespe Condor Sanctuary. This area, occupying a mountainous area north of Fillmore is utilized by the endangered California condor. This sanctuary and the normal activities of the condor lie beyond the Valley of the Santa Clara River where the pipeline is proposed to be located. However, the danger exists that construction personnel, if not fully aware of the bird and its precarious status, may kill these very large soaring birds during off-hour recreation.

Although the exact locations of such aeries are unknown, it is possible that breeding prairie falcons and perigrine falcons may be found within the corridor influenced by the proposed project. Disturbance could be expected up to a mile from the actual pipeline alignment. Both of these species are considered to be in need of special protection and the latter is formally declared to be endangered.

Socioeconomic Factors

Direct Economic Benefits--The principal beneficial effects resulting from construction of the project are economic. The total construction payroll (in 1974 dollars) over the 39-month construction period is estimated at about $46 million, of which $35 million will be disposable income. An estimated 90% of this amount ($31.5 million) will go to those residing in the Ventura County area and will, to a large extent, be injected into the local economy. Expected sales tax revenue on the taxable portion of these expenditures (estimated at $17.5 million) is as follows:

Cities and County (1%)	$ 175,000
State of California (5%)	875,000
Total Tax Revenue	$1,050,000

Building permit and plan-check fees paid to the City of Oxnard are based upon the value of construction and operation. In the event that repairs to the line are required, access to sites of possible malfunction will be gained from existing roads and trails, or along the right-of-way itself. New access roads will be constructed only as a last resort. Habitat disturbance and loss of plants and animals should be an uncommon occurrence during operation and, consequently, maintenance should have only limited impact on wildlife within or near the right-of-way.

The estimated construction cost of the proposed pipeline is $205,497,000 at a unit cost of $975,770 per mile per pipeline.

The California State Board of Equalization will assess the value of the pipeline. Local governments will add their proportional share to their tax base and tax revenues. Based on the taxation of other similar pipelines, it is estimated that the assessed valuation may range from $3500 to $4000 per lineal mile.

Sales tax revenues would be increased by expenditures made by the construction crews. However, the results would be beneath the threshold of detectability in the overall economy of the areas affected.

A very rough, and probably conservative, estimate of the increase in retail sales has been derived. The annual average per capita retail sales for Ventura County and Los Angeles County in 1973 was $2350 per capita. At three to four persons per family, retail sales would range from about $7050 to $9400 per family. Area retail sales from 740 families for nine months could range from $3,913,000 to $5,217,000. This would be a minor addition, even at the higher estimate, to 1974 taxable retail sales volume in either Ventura County ($903,000,000) or Los Angeles County ($18,781,000,000).

The construction project is expected to require a peak labor force of about 1,900 workers in the 8th quarter of construction.

This labor force will consist of employees of both the prime contractor and subcontractors. As of June 1974, the California State Employment Development Department had estimated that a total of 5,300 persons were engaged in contract construction in Ventura County. The project's peak requirement of 1,900 persons represents approximately 36% of that pool.

An estimated minimum of 90% of the peak required labor force will be drawn from within the Ventura County labor pool. Those from outside the county, estimated at about 200 persons, will fill certain specialized skills not readily available within this labor pool.

The construction labor required for this project is similar in scope and skills to that for the Ormond Beach Generating Station. Its construction began in 1969 and involved a peak of approximately 800 construction workers, most of whom were drawn from the Ventura County labor pool.

Gross direct wage payments (1974 wage scales) to the construction labor force over the duration of construction are estimated at about $46 million, excluding subcontractor labor.

At its peak, this construction project will be one of the largest "employers" in the Oxnard-Port Hueneme area, with the exception of the U.S. Government.

Population and Housing--The majority of the outside work force of approximately 200 is expected to come from the greater Los Angeles area. These workers will probably commute to the job site from their residences on a weekly basis. Although a small demand will be created in the Oxnard-Port Hueneme area for rental-type living accommodations (apartments, motels, hotels, and trailers), the total impact on housing demand will probably be insignificant.

The construction phase is not expected to attract new permanent residents to the area, except for certain employees whose responsibilities will carry over into the operations phase.

Urban Protective Services--The closest Oxnard Fire Department station is located at Pleasant Valley and Cypress Roads, approximately 1-1/2 miles from the construction site. The nearest fire station in Port Hueneme, served by the Ventura County Fire Department, is at Clara and Second Streets. No additional facilities will be required for either station. The U.S. Naval Station has its own fire department.

The above-mentioned fire departments have executed a mutual aid agreement in which the resources of all three would become available in an emergency. In addition to the land-based facilities, the Navy maintains 2 fireboats for offshore emergencies.

Neither the fire nor police departments are expected to require additional personnel or equipment for the construction phase. Control and direction of vehicular traffic on and around the sites will be accomplished with privately employed flagmen and and traffic patrols. All construction methods, procedures, and equipment will conform to the appropriate codes and standards. The required onsite hydrants, protective equipment, and emergency communications systems will be installed.

Schools--Because construction workers will be drawn primarily from the existing Ventura County labor pool, little relocation or importation of school-age children is anticipated. Consequently, there should be no significant impact upon the schools in the area.

Hospitals--Three hospitals are located in the general vicinity of the construction site. St. John's, a 316-bed general hospital 5 miles north of the proposed site, provides emergency treatment and is equipped with a helicopter landing pad. The Oxnard Community Hospital is a 49-bed facility located 4 miles north of the site. In Port Hueneme, emergency services are provided by Belinda Hospital, approximately 2 miles west of the site. No significant impact upon hospital facilities or staff is expected.

Utilities--The plant site is presently served by a 12-inch sewer line and a 12-inch city water main, both located in McWane Boulevard on the northern border of the property. The capacity of these lines should be sufficient for utility needs during construction.

After the transitory and temporary socioeconomic impacts of pipeline construction, which are generally considered to range from small to negligible, there are practically no measurably significant impacts from the proposed action in any socioeconomic area.

Labor and Housing--It is tentatively planned to employ about 740 persons in two construction spreads to build the proposed pipeline. Of these, approximately 130 will be specialists and will be temporarily in the construction areas, leaving when the work is completed. It is estimated that suitably skilled labor is available such that about one-third of the remaining 570 non-supervisory, non-specialist employees (about 190 persons) can be hired from the local communities. Undoubtedly, these would be drawn from the Oxnard-Port Hueneme area and the Newhall-Saugus-Valencia-Canyon Country area where the populations are concentrated.

Total wages paid during the 9-month construction period are estimated to be about $15 million. The total number of local persons to be hired (approximately 190) would have a beneficial, but negligible, impact on the unemployment rates, noting that both Ventura County and Los Angeles County are areas of substantial unemployment. The effect would be negligible even if all hired persons were drawn entirely from either county.

Similarly, the impact on housing would be negligible or unnoticeable. No severe deficit of housing exists in either population center.

Local Industry--Only minor purchases of supplies and materials that will be required during construction will be made locally. These will be a beneficial, but insignificant, impact on local industry. Major materials needed will come from outside the local areas.

Public Services--During the construction phase there will not be any appreciable additional loads placed on public services. The temporary presence of the non-local employees and families during construction (if families accompany these employees) would be an inconsequential addition to the existing populations.

Relocations--As tentatively designed, the pipeline corridor would result in the removal of a small number of trees from the outer limits of a few orchards; one poultry operation in the mountainous section of the proposed route might be slightly affected. No major impact on their respective production capabilities is likely. In the Santa Susana Mountain area at Tapo Canyon, the corridor would pass through some orchards located in the canyon floor. Removal of only a small number of producing trees would be likely. The effects on overall output would be negligible.

It is possible that three small manufacturing facilities in Saugus might be temporarily disturbed, but no major relocation appears to be required. Since the precise alignment is not known, these manufacturing facilities may be entirely bypassed and unaffected.

Effects on Human Environment--During construction, some transitory adverse effects may develop, but will be minimal. These would be limited to noise, dust, and vehicle and equipment movements congesting traffic flows. These transitory adverse effects, most noticeable in the populated communities at either end of the proposed pipeline corridor, are discussed in detail under other subheadings in this section.

Land Use

Construction--The proposed Oxnard LNG plant site is currently zoned for heavy industrial use. Construction of the proposed facilities would not have a significant adverse impact on land-use patterns in the Ormond Beach or greater Oxnard-Port Hueneme areas. During the approximately 39-month construction period, public access to the site will be restricted. However, as the immediate plant site is not used for recreational purposes, this restriction should be of little consequence.

Facilities--The project-related marine terminal receiving facilities will require leasing of approximately 34 acres of state-owned subtidal lands. The ship berthing areas will be located at the end of the pier-and-trestle complex, some 6,000 feet off Ormond Beach and approximately 2 miles southeast of the Port Hueneme Harbor south jetty. No construction on public-use land is planned, except for that area of Ormond Beach to be traversed by the trestle.

During the construction period, public use of sections of Ormond Beach may be interrupted from time to time. However, lack of suitable public access to the beach area presently limits its recreational value, and the actual impact of construction on public use will probably be temporary in nature and minimal in magnitude.

1. LNG Transfer Line. An approximately 8,000-foot-long cryogenic line will be constructed between the head of the pier and the plant site. A 2,000-foot section of the transfer line will be installed above ground on the plant site. However, this should have no impact on existing land uses on the site.

2. Vaporization Facilities. Applicant plans to use 210 acres of land for the proposed project. Of these 210 acres, 55 will be used for the plant site itself, and the remaining 155 will form a "clear" or buffer zone around the vaporization facilities. Since the property (located in the City of Oxnard) is currently zoned for heavy industrial use, and the area is master-planned for industrial use, the proposed land-use change should have an insignificant impact on future land use in the Ormond Beach industrial area. Although 55 acres of cultivated land will be converted to nonagricultural uses, this represents less than 0.05% of all land under cultivation in Ventura County during 1972.

3. Seawater Exchange Line. Four seawater exchange lines located along the southern boundary of the Southern California Edison property, will connect the LNG plant with the Ormond Beach Generating Station southeast of the site. Since the seawater exchange lines will be in a 50-foot-wide trench, they should have no impact on existing land uses.

4. Surrounding Area. It is estimated that the construction labor force will be largely derived from the existing Ventura County labor pool. Any increase in local population due to the in-migration of construction workers is expected to be minor and of temporary duration. Therefore, any new secondary land use requirements generated by the project in the Oxnard-Port Hueneme area (such as increased demands for housing and/or commercial improvements) will probably be minimal and insignificant.

Transportation facilities serving the Oxnard construction site are considered adequate, necessitating no further conversion of land use for that purpose.

Operations--

1. Land Use. The land-use patterns of the Oxnard-Port Hueneme area will not be substantially affected by the operation of the proposed facilities. The area in which the LNG vaporization facility and storage tanks are to be located is currently in agricultural use and is planned for industrial use. Surrounding existing uses are consistent with this plan.

The trestle connecting the offshore berthing facility with the plant site will impact a small section of Ormond Beach at the point where the trestle crosses the shoreline. The total beach area affected will be minimal, however, and public access to beach areas east of the trestle will be provided between the structure supports. Public access to the trestle itself will be prohibited as a security precaution.

The LNG transfer lines will impact land use only insofar as they might preclude other future uses (during the life of the project) of the actual space that they occupy.

The LNG facility, when operational, will employ an estimated total of 90 persons working three 8-hour shifts. The impact of automobile traffic resulting from operation of the LNG plant will be less than 1% of the present daily traffic and, therefore, insignificant. Heavy truck traffic to and from the site will be irregular and minimal, and should also have an insignificant effect upon traffic patterns in the area.

LNG ships are scheduled to begin deliveries approximately 3 years after the construction phase is initiated.

Although LNG ship arrivals (425 to 565 per year) will be twice as frequent as the 1974 level of Port Hueneme ship arrivals (242), there will be no adverse impact upon ship traffic within the port itself, 2 miles from the marine facilities.

Since these transportation facilities are considered adequate, no land use impacts are expected in this regard.

After construction of the proposed pipeline is completed, there will be some changes in land use over what originally existed. The majority of the right-of-way will be revegetated with grass or replanted in agricultural crops and generally restored to its original use and appearance. In the case of seasonal truck crops, the pipeline rights-of-way, including the area disturbed by construction, can be again used for previous purposes. In the case of citrus groves, the postconstruction land use impact may continue for a number of years. Any disturbed areas in citrus groves could remain nonproductive for 5 to 10 years until trees replanted in the right-of-way become profitable producers, unless the grower planted some other crop in the disturbed area.

During the operating life of the pipeline, it is envisioned that some maintenance or repair work may be required that would entail local damage to crops. The Applicant will negotiate suitable terms with landowners. It is important to note that in right-of-way negotiations the Applicant usually retains the right to carry out maintenance and repairs. Property owners are reimbursed for damage to crops or property.

The use of rights-of-way for roadways and access roads is common. It is possible that in establishing the right-of-way through certain fields, a patrol road may be maintained where none exists now. In such an instance, a small area would be removed from agriculture production.

Future land use with respect to recreation will not be adversely affected. In some cases it may be possible that the pipeline right-of-way could be incorporated in open space or park concepts.

Changes in industrial, commercial, and urban land use are expected to be very small if not insignificant. Existing uses will not be precluded; changes, if any, in future uses will only be limited to the actual right-of-way, where erection of permanent structures will be prohibited. No restrictions will be placed upon mineral or water resources by pipeline operation.

2. Traffic. Project operation and maintenance will not disrupt any existing or planned transportation corridors or facilities nor necessitate the construction of any such facilities. In the event of pipeline failure near or underneath a roadway or railroad, necessitating the replacement of a portion of the pipe itself, then traffic disruption due to repair and/or reconstruction activities may occur. Any disruption of transportation would be of very short duration.

Paleontological, Archaeological and Historical Sites

According to information currently available, it appears that construction activity associated with the project will not affect any known paleontological or archaeological sites. However, personnel of the University of California, Santa Barbara (1973) Archaeological Survey have indicated that other sites, yet undiscovered, may exist in the area.

Any paleontological or archaeological discovery during construction will be evaluated by qualified specialists before further disturbance or removal. Complete instructions for presentation are contained in federal statutes pertaining to salvage paleontology or archaeology. These statutes provide for the preservation of historical American sites, buildings, objects, and antiquities of national significance.

No significant historical sites or structures are known to exist within or immediately adjacent to the Oxnard site or the pipeline route. Thus, neither preparation of the site or right-of-way nor construction of the proposed facilities and pipeline would have an adverse effect on historical sites or structures.

It should be noted that the above assessment is made on the basis of archival research, without benefit of field reconnaissance. When final construction areas have been staked and flagged, this preliminary assessment will be verified by an inspection of relevant areas of the site.

Recreational and Esthetic Resources

Public access to the site will not be provided during the construction phase.

Access to the Hueneme fishing pier and the Port Hueneme Beach area of Ormond Beach is provided via Ventura Road, 2 miles west of the proposed LNG marine facilities. Construction of the marine facilities will not interfere with access to either of these areas. Any recreational use of Ormond Beach further eastward than 2 miles from the Hueneme fishing pier or the Port Hueneme Beach will be affected by construction of the marine facilities. The impact upon normal beach recreational use from construction of the LNG marine facilities should be insignificant.

Visual Impact--There is little existing industrial development in the vicinity of the proposed project other than Ormond Beach Generating Station which is visually dominant. The proposed construction will have a significant visual impact on residents of this area as well as on those who use its recreational facilities.

Owing to lack of an objective method of judgment, it must be assumed that human reaction to the sight of the proposed construction will be negative, although it is fully recognized that not all people will be equally affected by the visual exposure to the proposed facilities.

However, all large-scale construction activities generate temporary disturbances (dust, noise, and so forth), which create adverse esthetic impacts on the population in the area.

The operation of the plant will produce no visible emissions. It is therefore judged that there will be no detrimental impact on air clarity from plant operation.

Night illumination effects of the plant and LNG storage tanks will be minimized by the landscaping screens, planning of lighting direction and shielding. The lighting should have a negligible effect upon the residents and wildlife in the area.

Ships are a familiar part of the seascape and no adverse visual effect is expected to occur from viewing the LNG ships in transit or berthed at the end of the 6,000-foot-long pier.

Esthetic Values--Project operation and maintenance activities should not produce a significant visual or aural impact on the prevailing esthetic environment. Once construction has been completed, the majority of the construction right-of-way, with the exception of the fenced metering and valve stations, will be revegetated with natural grass or agricultural crops which should become reestablished in a short period of time (1 to 2 years).

All waste materials, trash from construction operations, litter from construction workers, and organic wastes from mobile sanitation facilities will be contained within the project right-of-way. They will be removed from the project site and disposed of in an acceptable manner prior to completion of the project. If burning of waste materials or vegetation is necessary, the required state and local burning permits will be obtained.

Physiographically, the corridor will be returned to its preconstruction form except in those instances where terrain necessitates large-scale grading operations. This might be expected to occur in the mountainous areas, particularly along ridge lines or steep slopes. The topography may be altered to such a degree that the pipeline route will be evident even after vegetative mitigation measures have been conducted (e.g., removal of mountain tops or peaks). However, these mountainous areas are relatively inaccessible to the general public, so while the visual impact may be of a significant degree, only a small segment of the population will view such impacts.

Air Quality

LNG Terminal--Construction of the Oxnard LNG vaporization facilities will not have a significant impact on the existing air quality of the area. During initial site preparation activities, brush and debris will be hauled away for suitable disposal. Therefore, there will be no air pollution from onsite open burning.

Movement of vehicular traffic, construction equipment, and other construction activities may cause localized short-term particulate loadings of vagrant dust in the atmosphere in the vicinity of the site. Amelioration or abatement of this problem will be accomplished by a program of wetting temporary roads and paving or oiling permanent construction and access roads, and restricting traffic when possible to these roadways. Additionally, any areas to be graded where significant amounts of earth moving are required will be wetted to reduce dust.

There will be only minor emissions of air contaminants from the site during the construction phase. Emissions will be limited to sources such as gasoline and diesel-powered construction equipment, and space heaters. Inconsequential emissions of volatiles and dust may result from painting and insulation application.

When it becomes operational while vaporizing approximately 3,000 MMcfd of high-purity natural gas, the proposed facility will emit some pollutants into the atmosphere. The sources of these emissions, the operating modes leading to the various emissions, the methodology for estimating the air quality resulting from these emissions, and the resulting air quality (environmental impact) are described in this section.

The primary pollutants of greatest concern have been found to be nitrogen dioxide (NO_2) and sulfur dioxide (SO_2). The air quality in the Ventura-Oxnard area already is somewhat degraded, but still meets state and federal standards for NO_2. As a result of plant emissions, air quality changes within a few kilometers of the plant might exceed the 1-hour peak standard (NO_2, California), but exceedances still are expected to occur less than once a year. Beyond a few kilometers, the air quality changes caused by plant operations will be undetectable.

Emission Sources--Natural gas will be used in the gas-fired vaporizers and trim heaters. The natural gas will have fairly high purity, with approximate composition as follows:

Gas	Quantity (Percent)
Methane	Greater than 85%
Total inerts	3%
Nitrogen	Less than 1.5%
Carbon dioxide	Less than 0.01%
Sulfur	0.5 grain per 100 scf
Remaining hydrocarbons (primarily ethane, propane and butane)	Less than 10%

Potentially harmful contaminants from combustion of this mixture will be minimal, particularly in comparison with other fossil fuel energy sources.

The emission characteristics of the various sources associated with plant operations were estimated by Fluor Engineers & Constructors of Los Angeles. The nature of each of these emission sources is described as follows.

Trim Heaters--Trim heaters are used to raise the gas temperature to 50°F prior to transmission. The emission rates for nitrogen oxides (NO_x) and sulfur dioxide are for peak operating conditions; it is expected that average operating conditions will be only 30% of these values. Nevertheless, peak emission rates are used in the estimation of impact on air quality.

Gas-Fired Peaking Vaporizers--During periods of peak gas demand the rate of vaporization of LNG will be increased by use of gas-fired peaking vaporizers. The emission characteristics are based upon studies performed on similar pieces of equipment. It is estimated that peaking vaporizers will be required no more than 480 hours per year. Full-capacity operation (4,000 MMcfd) was also assumed.

Seawater Heaters--Whenever heated water from the Southern California Edison Company Ormond Beach plant is unavailable, supplementary heaters will be used to prewarm the seawater used for vaporizing the LNG.

Emergency Relief System--If the plant must be shut down or operations drastically reduced so that the LNG, which is continually boiling off, must be vented to the atmosphere, automatic pressure venting will be provided through an elevated vent. Since the primary constituents of the gas are methane and other saturated hydrocarbons, no adverse impact on air quality will result.

Gas Odorizer--The gas is odorized in a completely closed system before transmission. The odorant tank, however, must be vented as it is filled. To prevent these odorous gases from escaping into the atmosphere, the vented gas will be passed through a sequence of activated charcoal filters. If any leak is detected from this filter system, the odorant tank refilling operation will be shut down and the vent closed until the filtration system can be adequately repaired or regenerated. In this manner, any significant release of contaminants from the odorizing system can be prevented.

Pipeline

Construction--Air contaminants would be emitted by construction equipment, the vehicles of workers commuting to the construction sites, and the controlled burning of trash, where allowed by permit. Soil particles would be stirred up by construction activities and by occasional strong wind over the disturbed ground. However, mobile construction sources of emissions are not expected to produce ambient concentrations that would significantly affect local or basin-wide air quality. Occasional controlled burning, blasting, and strong wind over disturbed terrain could cause temporary, local particulate concentrations in excess of air quality standards.

Operation--When the pipelines are in operation, the impact on air quality will be extremely small. Some natural gas will be vented at infrequent intervals and over very short periods of time at the Quigley Canyon, La Vista and Hinkley stations. This buoyant gas will rise and disperse rapidly within the lower atmosphere. No compressor station or other fixed emission sources are planned. The only emissions will come from the vehicular and aircraft traffic used in patrolling the pipeline route. Emissions from these sources should not affect the ambient air quality.

Environmental Noise

A construction site, with both stationary and moving equipment, is a complex noise source. The noise levels are functions of time, position, and type of work in progress. Studies of "typical" construction sites have been performed and "typical" levels reported. "A"-weighted noise levels, measured at 50 to 200 feet, ranged from 70 to 90 dBA. The measurements were made in communities with a 50 dBA ambient level, and they reflect the complexity of the source. The L_{50} noise levels measured for this project are similar to those in the communities described in the referenced report. The L_{10} or intrusive noise levels measured for this project are about 10 dBA above ambient noise levels.

Periodic checks will be conducted to insure that L50 levels in the community are not being severely affected. The project should have little impact on the present noise environment, because most work will be performed during the day. Careful selection of equipment and proper scheduling of construction, combined with adherence to OSHA requirements for worker hearing protection, will minimize construction noise impact. Contractors will be made aware of the noise-sensitive areas adjacent to the construction site. No blasting operations are anticipated.

There will be virtually no noise impact generated by operation of the pipeline. Valves and metering devices, which are the only source of noise, will be buried. Noise levels should attenuate to ambient levels within several hundred feet of valves or at the outer perimeter of the metering station.

8.2.6 Variation: Los Angeles Harbor to Yorba Station - Blythe - Eastern United States

Description of the Project

This variation to the alternative routes would locate the LNG Terminal and regasification plant on a land fill on Terminal Island, which is under the jurisdiction of the Los Angeles Harbor Department. LNG Terminal and regasification plant facilities would be generally the same as described in Section 8.2.1., Description of the Project. This variation is based on Dames and Moore, 1974.

The peak daily rate capacity of the regasification plant would be 3 billion cuft/day. One half of this volume would be destined for markets west of the Rocky Mountains and the remaining half would be routed through existing pipeline systems to markets in the eastern United States.

The pipeline system from the regasification plant would consist of one 48" diameter pipeline. The system would proceed northwest from Terminal Island to Yorba Station 36.4 miles northeast of Los Angeles. At this point the pipeline would be joined to the following existing pipelines: a 30" pipeline that runs west to Los Angeles and Quigley Station, a 34" line that runs north to Cajon Junction, and two 30" east-west pipelines that are part of a major transmission pipeline system transporting gas from the California-Arizona border. The single 30" pipeline to Quigley Station and the 34" line to Cajon Junction would be the major distribution lines for delivery of Alaskan gas to western and northern California. The two 30" east-west pipelines, with reverse flow capability and compressor modification, would deliver Alaskan gas to southern California and the California-Arizona border. The pipeline system extends across Arizona into southeastern New Mexico.

At Blythe, a 30" line in this pipeline system that has been proposed for abandonment would be utilized in conjunction with two other pipelines (a 26" and a 30" parallel pipeline system) to transport the Alaskan gas to the Keystone ML Station near Jal, in the southeast corner of New Mexico. From this point the gas would be hooked up with Waha Station, described in the prime alternative, Description of the Project.

Description of the Existing Environment

This segment of the proposed project would originate with the LNG terminal located on Terminal Island with the Los Angeles Harbor. A pipeline would transport natural gas eastward to Yorba Station where the pipeline would connect with existing pipeline systems. From Yorba Station gas would be transported through existing pipeline systems eastward through Blythe, California, to Texas and finally to the north and northeastern United States. A description of the environment for the sections east of Blythe is described under 8.2.1 of the EIS. Therefore the description in 8.2.6 applies only to the section from Los Angeles to Yorba Station.

Climate

The proposed LNG terminal site and pipeline is in an area designated by the State of California as the South Coast Air Basin. The climate of the South Coast Air Basin and in particular the valley floor area in which the proposed pipeline will be located is substantially moderated by the presence of the Pacific Ocean. The basin experiences long periods of light winds and ample sunshine. The surface wind conditions of the basin are generally from the ocean to the interior during the daytime and from the interior towards the ocean at night. During the late spring, summer, and early fall, onshore winds are prevalent, whereas during late fall, winter, and early spring the major wind flow is from the interior toward the ocean.

Because the large-scale atmospheric pressure patterns in the region do not allow high wind velocities, the distances which air masses are moved during a daily cycle usually is not great. The basin air is contained on three sides by mountain ranges and during most of the year is capped on top by an inversion layer. The height of the inversion base (the elevation at which the atmospheric temperature begins to increase with elevation) is around 1,300 feet MSL along the north coastal parts of the basin, increases to 1,500-2,000 feet MSL in the south, and 2,000-4,000 feet MSL in the interior areas. The inversion base height fluctuates daily, being lowest along the coast during late afternoon and early evening and lowest at inland areas during early morning hours.

During winter months when there is no storm activity, the South Coast Air Basin experiences radiation type inversions. These inversions are accompanied by fog and may persist for several days along the coast and some interior portions of the basin.

Visibility in the area is frequently restricted by haze, fog, or smoke that is encouraged to persist by the presence of an inversion layer. Low visibilities usually occur with weak winds but, at times, fog banks will be brought inshore by marine breezes. Fog can be expected occasionally during the summer and about one night, or early morning, out of every four during the winter.

The climate in the immediate vicinity of the proposed pipeline can best be described by the various climatic variables, which are measured at weather stations near the project site. Two weather monitoring stations (designated Long Beach and Yorba Linda) located along the pipeline were selected as measuring data representative of the project site.

Data of 15 years of record (1959-1973) for each station were analyzed. The mean monthly temperature does not differ significantly along the pipeline. For both stations the temperature variations during the year are not great, having mean monthly lows in the mid-50's during December, January, and February, and mean monthly highs in the mid-70's during July, August, and September. The maximum temperature during the summer months (June through October) normally exceeds 100°F and is quite often above 110°F. During the winter months (December through March) the minimum recorded temperature is around freezing (32°F).

Rainfall in the project area is relatively low, averaging about 10.4 inches per year at the Long Beach Station and 12.2 inches per year at the Yorba Linda Station. Practically all of the rainfall occurs during the winter months. The period May through October receives at most only a fraction of an inch precipitation. Thunderstorms do not occur often near the coast, but showers and thunderstorms are observed over the coastal ranges at times during the summer when moist air from the south and southeast invades Southern California.

Topography

The proposed route from Los Angeles Harbor to Yorba Station would traverse industrial areas of Los Angeles through relatively flat coastal plains that rise gently from 20 feet at the LNG site to 400 feet above sea level at Yorba Station. The lowland is bounded on the northeast by the

Puente Hills, on the east and southeast by the Santa Ana Mountains and San Joaquin Hills, and on the southwest by the Palos Verdes Hills and the Pacific Ocean.

Geology

Los Angeles Basin

The basin's central floor is buried beneath approximately 20,000 feet of Miocene and later sedimentary rocks. The southwestern shelf has a crystalline schist floor (the Western Bedrock Complex) that is 1,000 feet above sea level in the Palos Verdes Hills, mostly 4,000 to 10,000 feet below sea level north of these hills, and as much as 14,000 feet subsea beneath Long Beach. A similar shelf on the northern and eastern sides of the basin is floored by pre-Upper Cretaceous crystalline rocks (the Eastern Bedrock Complex) at depths ranging from 15,000 feet to approximately sea level.

The Los Angeles Basin was a deep marine trough at the beginning of Pliocene time. It was then filled successively with sediments containing fossils characteristic of shallower and shallower water until the uppermost, largely continental, Pliestocene strata were deposited. The basin is divided structurally into fairly well-marked blocks, mostly by major faults or fault zones. The Palos Verdes Hills block lies southwest of the Palos Verdes fault zone. The main west side block lies between the Palos Verdes and the Newport-Inglewood fault zones, and the central deep block lies between the Newport-Inglewood zone and the curved margin of the eastern shelf. The basin as a whole is bounded by the high standing blocks of the San Gabriel Mountains, the Santa Monica Mountains, and the Santa Ana Mountains. The unmetamorphosed Upper Cretaceous and Cenezoic sedimentary rocks are mostly marine and mostly clastic. Nonmarine, varicolored clastic sedimentary rocks are known at the base of the Upper Cretaceous section, at the base of the Paleocene section and in the Oligocene and Miocene formations. The white-weathering Monterey shale of Middle and Late Miocene age is marine, mostly nonclastic siliceous and thinly laminated. It is interbedded with coarse clastic strata.

Western Bedrock Complex (Catalina Schist)--The Catalina Schists in the Los Angeles Basin are composed chiefly of fine-grained, gray-green, chlorite-bearing schists, including moscovite-chlorite schist and moscovite-chlorite-quartz schist. Planes of schistosity in the Catalina Schist are well marked, very closely spaced and crumpled. Many laminae are present in each millimeter of rock. The crumpled foliation surfaces generally have average dips of less than 45°, and commonly are nearly parallel to the stratification planes in the overlying Miocene sedimentary rocks.

Middle Miocene Rocks--Middle Miocene sedimentary rocks are widely distributed and highly varied in the Los Angeles Basin. They include sandstone, conglomerate, breccia, diatomite, and organic shale. The coarse, clastic rocks of the Topanga formation contain shallow-water marine fossils and are present at the northwest, northeast, and southeast margins of the basin. Most of the middle Miocene sedimentary rocks are marine, and much of the Monterey shale may even be a deep sea deposit. Middle Miocene volcanic rocks, mostly calcic andesite flows, tuffs, and breccias, are found in almost all parts of the basin. They range from local thin beds of tuff to 3,000 feet of lava, breccia, and other rocks. Large dikes of diabase and andesite in the San Joaquin Hills radiate from the vicinity of Laguna Beach. They may be in part contemporaneous with the middle Miocene volcanic rocks, although one member of this dike complex cuts late Miocene Monterey shale.

Upper Miocene Rocks--Sedimentary rocks of the late Miocene age reach a maximum thickness of 11,000 feet in the Los Angeles Basin. They crop out in all of the hills surrounding the basin and are present beneath most of the alluvium-mantled central plains.

Pliocene Rocks--Marine sedimentary rocks of Pliocene age exist with thicknesses of at least 10,000 feet in the deep central part of the Los Angeles Basin and may be considerably thicker. In this central deep these rocks consist of interbedded, greenish-gray, micaceous siltstone and fine- to coarse-grained light gray feldspathic sandstone. Several conglomerates and fine rubble breccias are present locally and become more numerous toward the top of the Pliocene section. Indications are that these sediments were deposited in water more than 4,000 feet deep. During late Pliocene time, the sea shallowed gradually to about 900 feet. These rocks are also referred to as the Repetto formation.

Pleistocene Rocks--The Pleistocene geologic record is a complicated one involving marine and continental formations warping and middle Pleistocene angular unconformities at the margins of the basin. These sediments usually are marine along the ocean and become continental five to ten miles inland. In the central part of the Los Angeles Basin, continental sand and silt prevail on the surface to a depth of 3,200 feet. Below 1,050 feet some layers contain lagonnal and neritic Foraminifera. These beds are underlain by silt and sand that contain upper Pliocene Foraminifera of moderately shallow water facies.

Los Angeles Harbor

Bedrock Geology--Several bedrock outcrops are known to occur in the vicinity. Submarine outcrops occur about 1,000 feet south of Reservation Point. These are characterized by dark gray, hard porcelaneous shale and white, cherty silty shale. Dark olive-gray fine crystalline limestone and soft olive-gray mudstone have also been dredged from this area several hundred feet south of the former location of Deadman's Island. The remains of Weldt rock project 5 to 10 feet above the surrounding sediment in an area about 2,500 feet southeast of Reservation Point. This rock consisted of gray, medium-grain sandstone, well-cemented with calcium carbonate. Some of the rock was found to contain living pholads (rockboring molluscs).

Sedimentary Deposits--The character of the harbor bottom changed considerably as a result of harbor construction, and the discharge of wastes into the harbor waters. Sources of wastes include municipal sewage outfalls, fish cannery effluents, a variety of refining and industrial discharges, and vessels.

A layer of sludge has accumulated in some localities of the harbor. This sludge layer is thickest in the inner harbor and in Fish Harbor, where accumulations up to 7 or 8 feet are reported. Generally, the thickness of the layer decreases with distance from these 2 harbor areas, and is presumably absent in many parts of the outer harbor.

Recent National Ocean Survey charts of the harbor indicate that in the area of the proposed LNG ship navigation channel, green or black muds cover the sea floor surface in water depths greater than 20 feet, and gray sands and black muds are found at shallower depths. Most of the surface of the outer harbor bottom was covered with black sediment ranging from very fine sand to clay.

Stratigraphy

The proposed pipeline alignment crosses a number of different soil types. For discussion, these soils are classified according to soil association: groups of soil series that tend to occur in the same geographical area and named for the major soils it contains.

The pipeline passes through about 3 miles of Oceano association soils, about 3 miles of Ramona-Placentia association soils, 4 miles of Chino, about 8 miles of Hanford, one-half mile of Tujanga-Soboda, 6 miles of Foster, 2.5 miles of Sorrento-Mocha, 9 miles of San Emigdo-Metz, and 0.5 miles of Perkins-Rincon association.

Oceano soils are more than 60 inches deep, are excessively drained, and have rapid subsoil permeability. They have grayish-brown, slightly acid and medium acid sand surface layers about 4 inches thick, underlain by a light brownish-gray, strongly acid sand subsoil about 16 inches thick. The substratum is pale-brown, strongly acidic sand. These soils are highly susceptible to wind erosion if left unprotected. Available water holding capacity is 3.5 to 4.5 inches for 60 inches of soil depth. Inherent fertility is low.

Ramona soils in the Los Angeles basin are more than 60 inches deep, are well drained and have slow subsoil permeability. They are characterized by brown to reddish-brown, heavy loam, loam, or sandy loam surface layers about 18 inches thick. Subsoils are brown to reddish-brown, dense clay loam or clay about 30 inches thick. The substratum is brown to reddish-brown loam or light clay loam. Some subsoils may be stratified beds of silt to sand. Areas with up to 60 percent by volume stones and cobbles also occur. Available water-holding capacity is 8.0 to 10.0 inches for 60 inches of soil depth. Water-holding capacity is reduced by the percentage of coarse fragments in those areas containing stones and cobbles. Inherent fertility is moderate.

Placentia soils are more than 18 inches deep, are moderately well drained and have very slow subsoil permeability. They are characterized by brown to reddish-brown loam or sandy loam surface layers abruptly underlain by a dense, dark reddish-brown, clay loam subsoil at about 18 inches. The substratum occurs at about 48 inches and is brown loam. The dense subsoil restricts the movement of air and water and the development of roots and is, therefore, considered limiting for effective soil depth. Occasional areas have subsoils composed mainly of gravelly deposits and some have an iron-cemented hardpan. Available water-holding capacity is about 2.0 to 2.5 inches for 18 inches of effective soil depth. Inherent fertility is low.

Chino soils are usually more than 60 inches deep, are somewhat poorly drained, and have moderately slow subsoil permeability. They have gray and dark gray loam, silt loam or clay loam surface layers about 16 inches thick underlain by gray and light brownish-gray silty clay loam and clay loam substratum. They are calcareous throughout and mottled in the lower part. Some areas have a high water table, which restricts rooting depth. Some areas are saline-alkali affected. Available water-holding capacity is 10.0 to 12.0 inches for 60 inches of soil depth. Inherent fertility is high.

Hanford Association--Hanford soils are more than 60 inches deep, are well drained, and have moderately rapid subsoil permeability. They have pale-brown coarse sandy loam surface layers about 8 inches thick underlain by light yellowish-brown coarse sandy loam and gravelly loamy coarse sand substratum. Typically they are slightly acid to mildly alkaline throughout but occasionally are calcereous in the lower part. Thin layers of coarser material may occur below 40 inches. Available water-holding capacity is 5.0 to 7.5 inches for 60 inches of soil depth. Inherent fertility is moderate.

Tujunga-Soboda Association--Tujunga soils are more than 60 inches deep, are somewhat excessively drained, and have rapid subsoil permeability. They have brownish-gray or grayish-brown sand or loamy fine sand surface layers underlain by similar substratum that may be stratified. They are slightly acid to mildly alkaline throughout. In places these soils are subject to occasional overflow. Available water-holding capacity is 4.0 to 5.0 inches for 60 inches of soil depth. Inherent fertility is low.

Soboda soils are more than 60 inches deep, are excessively drained, and have very rapid subsoil permeability. They have pale-brown, neutral, cobbly very fine sandy loam surface layers about 3 inches thick underlain by pale-brown and light brownish-gray very cobbly loamy coarse sand that becomes calcareous in the lower part. Gravel and cobbles make up 35 percent or more of the soil profile. Available water-holding capacity is 2.0 to 3.0 inches for 60 inches of soil depth. In places, these soils are subject to occasional overflow. Inherent fertility is very low.

Foster Association--Foster soils usually are more than 60 inches deep, are poorly drained, and have moderate subsoil permeability. They have gray or grayish-brown sandy loam surface layers underlain by similar substratum that may be thinly stratified with variable textures. They usually are mottled and calcareous throughout. Other areas have a high water table that restricts rooting depth. Available water-holding capacity is 6.5 to 8.0 inches for 60 inches of soil depth. Inherent fertility is moderate.

Sorrento-Mocho Association--The Sorrento soils have grayish-brown, massive, hard, neutral, noncalcareous heavy loam surface soils. These are underlain by grayish-brown to light grayish-brown, subangular blocky to massive, slightly hard, mildly to moderately alkaline, calcareous stratified heavy loam or silt loam.

The Mocho soils have grayish-brown, subangular blocky, slightly hard, moderately alkaline, calcareous silt loam surface soils. They have grayish-brown to pale-brown, subangular blocky, slightly hard, calcareous heavy silt loam or silty clay loam subsoils.

San Emigdio-Metz Association--The soils of this association are well to somewhat excessively drained, calcareous, and are more than 5 feet in depth. Permeability is rapid to moderately rapid. Erosion hazard is none to slight.

The San Emigdio soils have grayish-brown, massive, slightly hard, moderately alkaline, calcareous fine sandy loam surface soils. These are underlain by light gray to very pale brown, massive, soft, moderately alkaline, calcareous, stratified fine sandy loam, sandy loam, and coarse sandy subsoils.

The Metz soils have pale brown, massive to single grained, soft, moderately alkaline, calcareous light sandy loam or loamy fine sand surface soils. These are underlain by brown to pale brown, massive, soft, moderately alkaline, calcareous stratified loamy sand, sand, loamy fine sand, and loamy coarse sand.

Included with these are some soils having stratified silt loam or very fine sandy loam subsoils. Some included soils have neutral to slightly acid surface horizons.

Perkins-Rincon Association--Perkins soils are more than 60 inches deep, are well drained, and have slow subsoil permeability. They have brown, medium acid, gravelly loam surface layers about 12 inches thick. The reddish-brown, slightly acid, gravelly clay loam or light clay subsoil grades into reddish-brown cobbly alluvium at about 48 inches. Available water-holding capacity is 7.5 to 9.0 inches for 60 inches of soil depth. Inherent fertility is moderate.

Rincon soils are more than 60 inches deep, are well drained and have slow subsoil permeability. They have dark grayish-brown, mildly alkaline silty clay loam surface layers about 13 inches thick. The subsoil is brown, moderately alkaline and calcareous silty clay about 22 inches thick. The substratum is yellowish-brown and white, moderately alkaline and very strongly calcareous silty clay loam. Available water-holding capacity is 9.0 to 10.5 inches for 60 inches of soil depth. Inherent fertility is high.

Erosion and Mass Wasting

The Terminal Island area is the only area where erosion would be a problem. There are no areas along the route where mass wasting occurs.

Seismicity

Southern California is a seismically active area of the Circum-Pacific Earthquake Zone and experiences several seismic events per year, although most of these are detected only by instruments.

In the Environmental Impact Study for the LNG plant on Terminal Island, Dames and Moore (1973) analyzed the frequency of occurrence of earthquake events and developed recurrence curves for various earthquake magnitudes and intensities. Their study covered the Los Angeles Basin, which includes the location of the pipeline and the Yorba Station. From this study, a magnitude 6 earthquake may occur once in 580 years within a 1,000 square kilometer area in the pipeline vicinity.

Faults Significant to the Site--Major faults in the vicinity of the pipeline route are the (1) San Andreas Fault, (2) Whittier Fault, (3) Newport-Inglewood Fault, and (4) Palos Verdes Hills Fault.

The largest of these faults is the San Andreas, which is located approximately 40 miles northeast of the project area. The San Andreas is a right lateral strikeslip fault with cumulative offset since Pliocene time on the order of 40 miles. This fault must be considered as a potential source of ground motion at the site.

The Whittier fault zone crops out at the surface in a slightly sinuous, locally branching line that trends about N 70° W from Whittier to Corona.

The zone nearly parallels the major faults in the San Gabriel Mountains and other transverse ranges north of the Los Angeles Basin; possibly the zone is a secondary fracture to the big bends in the San Andreas fault system.

The Newport-Inglewood fault system is the major structure in the Los Angeles Basin. A right-lateral displacement of 3,000 to 5,000 feet has been suggested for this fault, which separates basement rocks of granite character on the northeast and metamorphic character on the southwest. Continuing activity along this fault is demonstrated by numerous seismic events including the Long Beach earthquake of 1933. The proposed pipeline crosses the Cherry Hill fault of this system at about Del Amo Boulevard.

It is most unlikely that the Palos Verdes Hills Fault or the Whittier Fault will have movement during the life of the project. Movement on the San Andreas or Newport-Inglewood Fault is conceivable and would be associated with events of magnitude 8 and 7, respectively.

The pipeline alignment crosses the concealed fault trace of the Cherry Hill Fault of the Newport-Inglewood Fault Zone. The zone is known to be active and has caused at least five destructive earthquakes since 1920. The affected areas are tabulated below:

Place	Year	Intensity
Inglewood	1920	VIII
Long Beach	1933	IX
Santa Monica	1940	VI
Gardena	1941	VII
Torrance	1941	VIII

Ground accelerations have been held to be related to intensities and such accelerations have been successfully applied to design of moderate-sized structures. Intensity IX events expected in this area can be assigned an acceleration of 0.4g to 0.6g.

Water Resources

Surface Water

The proposed pipeline will cross five water courses between Long Beach and Yorba Linda. From west to east, these water courses are the Dominguez Channel, the Los Angeles River, the San Gabriel River, and Coyote Creek (a tributary of the San Gabriel River). The five channels drain a total of about 1,570 square miles of the Los Angeles Basin, San Gabriel Basin and the San Fernando Valley into San Pedro Bay at Long Beach.

The Dominguez Channel has a design capacity of 16,900 cubic feet per second (Jordan, personal communication, 1974) and an average flow of 16,000 acre feet per year, most of which occurs in the winter.

The design capacity of the Compton Creek channel is 13,750 cubic feet per second. The channel drains about 25 square miles of the urbanized Watts area and discharges into the Los Angeles River. The average yearly discharge is about 6,060 acre feet. The channel carries flows during the entire year with peak discharges occurring during the winter months. Based on a 1927 to 1972 record at a gaging station approximately 5 miles upstream of the pipeline crossing, the historical peak discharge in the channel was 6,000 cfs on December 27, 1972.

The banks and bed of the Los Angeles River channel are concrete lined. The channel capacity just downstream of the pipeline crossing is 146,000 cfs. Data collected at a gaging station located approximately 5 miles downstream of the pipeline crossing indicate an average yearly discharge of 120,000 acre feet and an historical peak discharge of 102,000 cfs occurring on January 25, 1969. There is flow in the river during the entire year with peak discharges occurring during winter months. The drainage area upstream of the gaging station is 832 square miles. (This area includes the drainage area of Compton Creek.) Flow in the river is partially regulated by the Sepulveda flood control reservoir and several small flood control reservoirs.

The channel bed and banks of the San Gabriel River are concrete lined. The channel is capable of containing a flow of approximately 60,000 cfs. Historical flow data are available from a gaging station located about 5 miles downstream of the pipeline crossing. At the gaging station the drainage area is 472 square miles. The 43 years of record indicate an average annual discharge of 20,430 acre feet. An historical peak discharge of about 27,000 cfs occurred March 2, 1938. Normally there is no flow in the river for several months during each year. Flow in the river is regulated by several upstream flood control reservoirs and diversions to percolation basins.

The channel bed and banks of Coyote Creek are concrete lined. The channel is capable of containing a flow of about 80,000 cfs. Historical flow data are recorded at a gaging station located just below Spring Street approximately 5 miles downstream of the pipeline crossing. The drainage area at the gaging station is 185 square miles. The data indicate a mean annual discharge of 24,435 acre feet and an historical peak discharge of 11,300 cfs occurring on January 20, 1969.

Surface Water Quality

The water quality in the Dominguez Channel depends on the amount and type of industrial discharge and storm runoff. The channel drains a relatively small area (80 square miles), which is intensely urbanized. In the past, the channel received a great deal of industrial influent, which resulted in very poor water quality. However, the amount of industrial discharge has been reduced due to a directive from the Los Angeles Regional Water Quality Control Board. Limited water quality data on the Dominguez Channel were available from the Los Angeles Regional Water Quality Control Board.

These data indicate an average dissolved oxygen content of about 4.9 parts per million and an average pH of 8.0. The measured hardness in 1973 was found not to vary greatly, generally about 4,800 milligrams per liter except for March when the hardness was measured at 2,310 mg/l. For the months of June through October, total dissolved solids averaged 26,500 mg/l with a range from 25,900 to 26,900 mg/l. For the months March through October, the biochemical oxygen demand averaged 5.0 mg/l with a range from 3 to 9. For the March through October period of 1973, the measured total coliform count per 100 milliliters ranged from a low of 100 to a high of 29,000. However, the 29,000 occurred only in March, whereas the other months averaged 1,460. The location of the measurements is Wilmington Avenue, which is in the zone of tidal influence. Dominguez Channel probably transports very little sediment because it drains an urbanized area and is concrete lined in some portions or has a natural or imported clay bed with riprapped banks in the remaining portions.

Compton Creek also drains a small urbanized area. The channel is concrete in part and has a natural bed with grouted stone banks in the remaining portion. However, the natural bed contains clay sediments and therefore the channel would not be expected to transport much sediment, especially with its normally small discharge. Limited water quality data for this creek were also available from the Los Angeles Regional Water Quality Control Board. The following tabulation summarizes these data:

Date (1974)	Dissolved Oxygen, ppm	pH	BoD mg/l	Total Coliform/ 100 ml	TDS mg/l
Jan. 16	7.3	7.5	0.8	2400	788
Feb. 6	10.1	7.6	4.8	6.2	620
Mar. 6	7.2	7.4	4.7	1.3	662
Apr. 3	11.8	7.4	9.5	1300	202
May 1	3.1	7.0	1.2	24	218
June 5	6.2	9.1	126.7	70	948
July 3	8.7	7.7	3.2	240	742

This water quality monitoring station is outside the limits of tidal influence.

Water quality in the Los Angeles River, San Gabriel River, and the Santa River varies depending on the runoff and waste discharges into the rivers. (The Santa Ana River does not cross the proposed pipeline route, but parallels the route for a short distance and could therefore be affected by construction.) All of these rivers drain fairly large areas with many tributaries, some of which pass through undeveloped areas. During periods of high runoff these rivers could be expected to transport sediment to San Pedro Bay. It is reported that the Los Angeles River transports considerable sediment to the bay, which is dredged and used as fill by the City of Long Beach. Water quality data for the Los Angeles River, San Gabriel River, and Santa Ana River are presented in Table 8.2.6.-1.

Coyote Creek drains mostly developed areas, but some drainage comes from undeveloped areas. The creek probably transports some sediment to San Pedro Bay. Only limited water quality data were available from the Los Angeles Regional Water Quality Control Board. The following is a tabulation of the available data:

1974	Dissolved Oxygen, ppm	pH	Total Coliform/100 ml
Jan. 16	5.5	7.9	25,400
Feb. 21	6.7	8.0	40
Mar. 19	6.7	8.2	>80,000
Apr. 5	7.7	7.8	<200
May 21	5.0	8.2	25,800
June 18	7.4	8.0	<20
July 18	9.1	7.9	1,000

No information was available to explain the large and rather regular variation in the coliform count. These data should be considered questionable.

Table 8.2.6-1 Water quality at selected stations on the Los Angeles, San Gabriel and Santa Ana rivers

	Discharge (cfs)	Temperature (°F)	Dissolved Oxygen (MG/L)	Dissolved Calcium (MG/L)	Dissolved Magnesium (MG/L)	Dissolved Sodium (MG/L)	Dissolved Potassium (K) (MG/L)	Bicarbonate (HCO3) (MG/L)
Los Angeles River*	17.6	64.8	11.0	81.3	27	118	8.5	179
San Gabriel** River	99	70.1	11.5	81	28	96	6.9	182
Santa Ana River	300	58	---	45	12	45	14	145

	Carbonate (CO3) (MG/L)	Dissolved Sulfate (SO4) (MG/L)	Dissolved Chloride (CL) (MG/L)	Dissolved Fluoride (F) (MG/L)	Nitrate (NO3) (MG/L)	Dissolved Boron (B) (UG/L)	Dissolved Solids (Residue at 180 C) (MG/L)	Dissolved Solids (Tons per acre foot)	Dissolved Solids (Tons per Day)
Los Angeles River*	0	246	99	.8	19	480	761	1.04	34.8
San Gabriel River**	1	236	89	.5	14	243	646	.88	179.9
Santa Ana River	0	68	49	.25	6	590	380	--	--

	Hardness (CA,MG) (MG/L)	Non-Carbonate Hardness (MG/L)	Alkalinity as CACO3 (MG/L)	Percent Sodium	Sodium Absorbtion Ratio	Specific Conductance (Micro-mhos)	PH (units)	Turbidity (MG/L)
Los Angeles River*	314	165	149	45	2.9	998	8.0	26
San Gabriel River**	319	168	151	38	2.3	1014	7.8	25
Santa Ana River	160	---	---	35	---	536	7.0	--

*Values averaged from six measurements taken between October, 1970, and September, 1971

**Values averaged from sight measurements taken between October, 1970, and September, 1971

Source: Dames and Moore, 1975, Vol. IV

Water Quality of Los Angeles Harbor

Water temperatures vary from 64.2°F to 65°F at the surface and from 64.2°F to 65.8°F at a depth of 36 feet. Salinity ranges from 33.9 to 32.4 ppt. The dissolved oxygen content in the inner harbor is low, approximately 6.5 ppm. The biological oxygen demand near the LNG site is greater than the dissolved oxygen content. The overall quality of the water is very low due to the wastes and effluents discharged into the harbor.

Groundwater

The coastal plain of Los Angeles and Orange Counties is underlain by sediments containing a large body of fresh water.

The groundwater basin consists of a thick sequence of Quaternary and Tertiary sediments deposited on a basement of pre-Tertiary age crystalline and metamorphic rocks. The lower part of the Quarternary sediments contain water-bearing sands and gravels that extend from the foothills to the ocean in two tongues, one through the Dominguez Gap and the other through the Santa Ana Gap. The underlying Pleistocene sediments include the important San Pedro member, which yields large quantities of water from the Silverado zone aquifer in the Long Beach area. The older Pliocene and Miocene sediments contain fresh water in their upper zones but are of lesser importance as a water supply because of their great depth (Poland and Piper, 1956).

There are two bodies of fresh groundwater. The upper body is shallow, semiperched and generally of inferior quality. The principal aquifers consist of coarser sediments that are essentially confined between layers of silt and clay, except in the aforementioned permeable reaches of the San Gabriel River and Rio Hondo downstream from Whittier Narrows and along the Santa Ana River.

A dominant geologic feature of the area is the Newport-Inglewood uplift, which extends from Newport Beach northwesterly to Beverly Hills. It is an anticlinal fold from which rocks dip downward, both oceanward and landward. Numerous discontinuous faults cut the rocks along the fold. The fold has uplifted aquifers, so that the base of the principal body of groundwater is about 1,000 to 2,000 feet below sea level along the fold, as compared to as much as 8,000 feet below sea level in the central part of the Downey Plain. The uplift exerts a partial barrier effect on groundwater movement and forms the boundary between the Central Groundwater Basin to the northeast and the West Coast Basin to the southwest. The proposed gas pipeline crosses the Newport-Inglewood uplift in the reach extending along Del Amo Boulevard, Susanna Road and the Los Angeles River crossing.

Several hills, such as Baldwin Hills, Signal Hill and Newport Mesa, mark the surface expression of the Newport-Inglewood uplift. Along the coast the hills are broken by a series of low-lying gaps through which salt water intrusion into the underlying aquifers has occurred in places. The intrusion has been induced by heavy pumping of wells and the consequent reversal of the normal oceanward gradient of the groundwater. To prevent the contamination of the underground basin by sea water, Los Angeles and Orange Counties have implemented systems of hydraulic barriers at certain of the gaps. The Alamitos Barrier Project was begun in 1965 under a cooperative agreement between the two counties and has now halted the saline intrusion occurring near the mouth of the San Gabriel River. Los Angeles County has similar projects at Dominquez Gap and West Basin, and Orange County has begun a project that will protect the 12 miles of coast along Talbert Gap, Bolsa Gap and Sunset Gap. In addition to the barrier projects, both counties have extensive groundwater replenishment operations in which surface runoff and imported water purchased from Metropolitan Water District are percolated into the subsurface along Santa Ana River, San Gabriel River, Rio Hondo and elsewhere.

Vegetation

The only vegetative type encountered along the route is grassland. Most of the species that occur are "weeds" or annuals characteristic of disturbed or neglected sites. There are no endangered species along the route. Due to the heavy development along this route, the human influence on the existing vegetation would be slight and incremental.

Wildlife

Inland

Only a limited number of animals has been reported or observed, undoubtedly due to the lack of suitable habitat and high population density over the majority of the route. The total potential animal population, ruling out seasonal and other factors, is therefore considered to be quite small, even in the Yorba Linda area, because of the proximity of urban and current agricultural development.

Birds represent the most diverse and valuable animal resource of the harbor area. The bird fauna in the area (some 22 species) is as rich in species as most similar localities along the Southern California Coast. There were few sightings along the pipeline route at the East Basin Channel, however.

Although no systematic survey has been conducted, virtually no mammals reside in this area. Those present include rats, gophers, and rabbits. Gopher snakes were observed, evidence of the existence of rats and gophers sufficient to support a small snake population.

Marine

In the inner and outer portions of Los Angeles-Long Beach Harbor and the adjacent portion of San Pedro Bay, three major marine habitat types are known: soft sedimentary bottoms; hard substrate provided by breakwaters, riprap jetties, and wharf pilings for bottom and near-bottom species; and relatively shallow open water for pelagic species. Of these 3, the least abundant and the least studied habitat type is the artificial hard substrate.

The soft bottoms in San Pedro Bay range from silts and clays through sands to rocks and pebbles. Most of the bottom is fine sand and silt; the harbor bottom is olive gray sand, silt, and clay. The organic content of the muddy bottom is high in the inner harbor and adjacent to the cannery and sewer outfall in the outer harbor and in Fish Harbor, and decreases seaward. The waters in the aforementioned areas with high organic content in the sediment are the most polluted in the area. These are the areas with large populations of pollution-tolerant species such as the polychaetes Capitalla capitata, Capitita ambiseta, Nereis procera, and Tharyx parvus, the pelecypod Macoma nasuta, and fishes such as the White croaker, Genyonemus lineatus. The number of species in the water column and benthos increases seaward.

In the outer harbor there are 3 major groups of fish. The croakers are found on bottoms closer to the shore of Terminal Island. A rockfish assemblage inhabits the bottoms landward of the breakwater in the central area of the harbor. The area from Angel's Gate to Fish Harbor is inhabited by large numbers of flatfishes, primarily the Speckled sanddab Citharichthys stigmaeus. The distribution of the fish assemblages in the harbor is in part dependent on the effects of pollutants. The most polluted bottoms seem to lack bottom fishes such as flatfishes, but support large populations of White croaker (Genyonemus lineatus) and Queenfish (Seriphus politus). These 2 species live in the water column but feed on the bottom.

The only commercially important fish in the harbor and San Pedro Bay is the Northern anchovy (Engraulis mordax). The fishery within the harbor is for live bait, these populations providing at least 80 percent, and probably more, of the yearly bait catch.

The San Pedro Bay area, including Los Angeles Harbor, supports a large sport fishery that has been increasing over the past few years. The most important species are rockfish (Sebastes spp.), accounting for 68 percent of the catch in 1973, Pacific bonito (Sarda chiliensis) at 10.2 percent, and sculpin (Scorpaena guttata) at 6.5 percent, with lesser quantities of Pacific mackerel (Scomber japonicus), rock bass (Paralabrax), Ocean whitefish (Caulolatilus princeps), Jack mackerel (Trachurus symmetricus), Yellowtail (Seriola dorsalis), and Halfmoon (Medialuna californiensis). In the harbor there is a large sport fishery for the White croaker (Genyonemus lineatus) (Stephens and others, 1974).

Marine Mammals--Only the Harbor seal is likely to be seen in Los Angeles Harbor, and that is infrequently.

Marine Birds--Fifty-three species of birds in the area are associated with open water, and 8 species are exclusively oceanic, the others being associated with continental shorelines. The most notable of these are 17 species of gulls and terns, 7 species of murres and auklets, 7 species of ducks and geese, 3 cormorants, and the California Brown pelican (Pelecanus occidentalis californicus).

The California least tern and the California brown tern are the only endangered species of birds.

Ecological Considerations

Harbor Environment

Terminal Island, the East Basin Channel, and the Wilmington-Carson areas, comprising approximately 5 miles of the pipeline route from Los Angeles Harbor inland, are areas of intense industrial activity. Habitat alteration, in the form of land reclamation and building, undoubtedly long ago displaced most of the more important endemic terrestrial organisms. Fish and other marine organisms found in the inner harbor area are restricted to species tolerant of high organic bottom and low oxygen concentrations. The species that occur, in fact, suggest a habitat that is not healthy. Most of the plant species observed are "weeds" or annuals characteristic of disturbed or neglected sites.

Inland Environment

The remainder of the pipeline route not covered in the preceding section, from North Long Beach eastward some 30 miles to within one-half mile of the eastern terminus at Yorba Station, has undergone a high degree of residential and commercial development. Only the last half-mile of the route is undeveloped and shows potential of containing some valuable biological species.

Economic Factors

The Los Angeles-Orange County area of Southern California has been an area of healthy economic growth and employment for many years. The labor forces of Orange County and Los Angeles County are closely correlated with each other. Manufacturing and trade provide approximately half of the employment with services and government supplying another third.

Economic indicators such as personal and family income, employment, taxable retail sales, and new construction indicated substantial continued growth as recently as 1972.

Industries along the western (harbor) end of the pipeline are primarily heavy (petroleum, chemicals); in the central section along South Street and Orangethorpe, commercial and retail; and retail and agricultural in the western segment in suburban Orange County. Agricultural employment is declining due primarily to increasing urbanization.

Total tonnage shipped through the port of Los Angeles has increased from 19.9 million tons in 1940 to 25.5 million in 1972. Petroleum shipments, while comprising about 70 percent of the tonnage, have remained stable for the past 20 years. Lumber shipments have declined to one-third the 1940 level, and general cargo has more than doubled in the recent decade, primarily due to the growth of Southern California and the introduction of containerized freight.

Agricultural production is stable or declining due to increasing urbanization in Orange County. Price inflation of foodstuff and other agricultural products is tending to offset declining production rates in determining total agricultural production values.

Agriculture continues to constitute a major portion of the Orange County economic base.

Sociological Factors

In this section, baseline social factors within the project area are discussed on an historical and projected basis. Land use conditions along the pipeline route are quite diversified, ranging from the mature industrial sections of the Los Angeles Harbor area to the undeveloped countryside and fruit groves of suburban Orange County nearly 40 miles east.

An estimated 150,000 people reside in a 1-mile strip encompassing the entire length of the proposed 37 mile pipeline.

Population densities average about 4,000 people per square mile along the pipeline route, ranging from a thousand or fewer in the Wilmington-harbor area to a maximum of 8,000 in Lakewood near the midpoint, to 3,000 per square mile in the Yorba Linda area of the eastern terminus. The project as presently envisaged will not require relocation of any residents.

Los Angeles County in 1970 reached a population peak of 7,041,000 residents, a gain of approximately 15 percent over the decade, and has since experienced a slight decline in population, the first in history. The latest Department of Finance and Southern California Associations of Governments (SCAG) official estimates project a stable population in the county to 1980 and slow growth (0.5-1.0 percent annually) thereafter.

Orange County has experienced a spectacular growth rate in the recent past, more than doubling in population in the decade of the 1960's and leveling off to an annual growth rate of approximately 4 percent during the 1970's. The county will continue to grow at a slower, steadier rate characteristic of maturing regions. A long-term growth rate of approximately 2 percent annually is projected. The greatest new growth is expected to occur in the southern coast and interior areas, not in the northern part of the county intersected by the pipeline and the area of greatest growth in the recent past.

Housing units have increased at a rate slightly greater than the rate of population increase in both Los Angeles and Orange Counties. The average number of people per unit is declining while housing value and the number of rooms is increasing. A continuation of these trends can be expected.

Land Use

The pipeline route passes through the heavily industrialized and residential sections of Los Angeles and Orange Counties. It is anticipated that urban sprawl will continue with an effort by planners to establish lower land use intensities for newly urbanized areas.

Agricultural land is limited and is disappearing due to urban sprawl. The only agricultural land that will be directly affected by the pipeline is along a 2,500-foot section that passes through field crop acreage in Orange County.

In fiscal year 1973 there were 3,169 ship arrivals into the Port of Los Angeles, an increase of 483 arrivals over 1972. This traffic constituted 1,728 general cargo vessels, 742 tankers, 234 cargo passenger vessels, 161 lumber ships, and 304 vessels calling for bunkers only. During fiscal year 1973 there were 18,012,639 short tons of petroleum shipped through the harbor, approximately 69 percent of the total short ton weight shipped through the port. However, since the post-World War II era, general cargo traffic has increased significantly in volume.

The ocean environment that is associated with the proposed pipeline consists of a relatively small and secluded portion of San Pedro Bay. San Pedro Bay is protected from ocean wave action by a series of breakwaters, which run from Point Fermin in San Pedro to Seal Beach, located in Orange County at the Los Angeles County boundary. The eastern half of San Pedro Bay shoreline consists of beaches, whereas the western half is composed of Long Beach Harbor, Los Angeles Outer Harbor, Los Angeles Inner Harbor, and Terminal Island. It is through the Los Angeles Inner Harbor that the proposed pipeline route is located.

The Los Angeles Inner Harbor is separated from the main bay by Terminal Island and consists of the Main Channel, Turning Basin, the West Basin, the East Basin Channel, the East Basin and part of Cerritos Channel (up to Henry Ford Avenue). The Main Channel running through the Inner Harbor is about 4 miles long and ranges in width from 600 feet in the Cerritos Channel to 1,000 feet in width in the Main Channel. The water depth in the Inner Harbor is a minimum of 35 feet throughout and is maintained by dredging.

Total water surface area is approximately 1,000 acres. The tide range at Los Angeles is 5.4 feet, making the tidal prism about 240 million cubic feet. With this relatively small tidal prism, the maximum tidal currents in the harbor channels would be less than 1 foot per second.

Archeological and Historical Features

Archaeology

The Southern California coastal zones, inland valleys, and adjacent foothills from San Pedro to Yorba Linda are known to have been continually inhabited by man for at least the last 8,000+ years, and probably much longer. The aboriginal people who lived in these areas were grouped together into various-size hunting and gathering bands. Whether they utilized an area permanently or intensively even for short periods, they left behind traces of their habitation. These traces remain today as archeological sites: villages, campsites, rock shipping stations, rock paintings, shell middens, and other similar modifications of the local natural environment. Many sites have been located already, especially along the coastal zone, but it is extremely likely that a number of sites have yet to be located. It is even more likely that the vast majority of the archeological resources that once existed in the area already have been destroyed. Because so few sites still remain, it is extremely important that they be located, examined, and preserved for future study.

A check at the Archeological Survey, University of California, Los Angeles, revealed that at least one recorded site lies directly in the path of the pipeline. Several other sites are in extremely close proximity to the pipeline route and there exists a good chance that as yet undiscovered sites may also lie in its path.

The site lying directly along the proposed route is near Atwood. Although it has been largely destroyed for investigative purposes, artifacts have turned up in the sand and gravel quarrying that is currently in operation in the area. This has led to suspicions that other areas in the immediate vicinity may be of archeological significance. Three other known sites have been recorded in the same general area near the towns of Placentia and Atwood. These three sites may also have been disturbed in the course of land development over the past few years.

In the Los Angeles County section of the proposed route, there are several other sites that lie very close to the pipeline.

Historical Features

The first Europeans to explore the area belonged to the expedition of the Spanish Governor, Don Gespar de Portola, who traveled along the coast in 1769 on his way to Monterey Bay. The missions at San Juan Capistrano and San Gabriel were established later in the eighteenth century and the great ranchos began to take form early in the nineteenth century, first under the Spanish and later under the Mexican rule.

Adobes were built by descendants Don Bernardo Yorba and Ramon Peralta near the mouth of Santa Ana Canyon. The former adobe has been destroyed and the site indicated by an historical marker on Esperanza Road, east of Imperial Highway, in Yorba Linda. Nearby is the Yorba Cemetery where early pioneers were buried. The Ontiveros adobe, located at 330 East Crowther Avenue in Placentia, was built about 1837 by Don Patricio Ontiveros. It is the oldest and best preserved in northern Orange County.

La Casa del Rancho Los Cerritos, adjoining the Virginia Country Club in Long Beach, is the largest and most magnificent adobe in Southern California. For many years it was owned by the Bixby family and is now the property of the City of Long Beach. Of more recent historical interest is the birthplace of former President Richard M. Nixon at 1806 Yorba Linda Boulevard in Yorba Linda. Mr. Nixon was born in this house in 1913 and lived there until he was nine.

Recreational and Esthetic Resources

Recreational opportunity in the heavily industrialized and residential area is limited to three golf courses and a number of small parks scattered through the region. Esthetics are those associated with a heavily urbanized area with its monotonous and often drab vistas of factories, housing, warehouses and railroads encased in the dirt, dust, and smog typical of cities. Small, scattered pockets of open space and agricultural lands and parks offer limited relief from the visually unvaried aspect of a heavily urbanized region.

Air Quality

The unique meteorological and geographical features of the South Coast Air Basin make the area extremely sensitive to air pollution. The basin is bounded on three sides by mountain ranges and on the southwest by the Pacific Ocean. The atmospheric pressure patterns in the area normally allow only very weak winds. The basin also receives an abundance of solar radiation. As a result of these factors, there is during most of the year an inversion layer capping the underlying marine air in the basin. The weak wind conditions of the area, which alternate from onshore to offshore on a daily cycle, do not allow an effective exchange of air masses. The poor air mass exchange allows pollutants to build up in the atmospheric sublayer of the basin to high levels. The air quality problems are increased by the high population, industry, and automobile density of the basin.

Environmental Noise

The project area has the usual city type noise of traffic, sirens, people, jet aircraft overflights and industry plus harbor noise at the western end of the route. The construction phase of the pipeline will create additional noise on a temporary basis. The operation of the project will not add to existing noise with the exception of the noise associated with the unloading of the LNG tankers and the operation of the regasification plant.

Impact Analysis

Summary of Major Impacts

The major impact that climate would have on this route would be caused by the fog and smog conditions of the Los Angeles area. Prolonged periods of fog, or even short periods, would restrict visibility in the harbor, posing a safety hazard and a delay in shipping. In the case of a gas spill the vapor cloud of gas would pose a fire hazard if held in the Los Angeles area due to an inversion condition.

The high potential for earthquakes with a magnitude of 6 to 8 is a major impact on the integrity of the pipeline. The area of this route has many fault systems that add to this risk. The Palos Verdes Fault is to the west of the pipeline, the route would cross the Newport-Inglewood Fault Zone and the Whittier, Chino and San Andreas Faults are to the east of Yorba Station.

The potential for loss of life and property due to an accident involving an LNG tanker, the LNG terminal or the pipeline is high because of the large population of the Los Angeles area.

The potential for a collision between an LNG tanker and another vessel in the Los Angeles Harbor area is high due to the heavy traffic at present and, if oil tankers will be using the harbor in the future, the risk would be even higher.

Detailed Analysis

Climate

The operation of the regasification plant and LNG tankers within the Los Angeles Harbor could add a small increment to smog conditions in the Los Angeles Harbor area. Otherwise construction and operation of the pipeline project should not have a significant impact upon the environment.

Topography, Geology and Soils

Construction of the proposed LNG facilities will result in minor terrain modification. The site lies on reclaimed land that has been utilized for rubble and hydraulic fill disposal. Material will be excavated for installation of the 4 LNG tank foundations and concrete dikes. The material removed from excavation will be used as fill on the site or adjoining Los Angeles Harbor Department property.

No increase in erosion, subsidence, settlement, or overly steep slopes is expected as a result of construction.

Construction of the facilities will not deplete any mineral resources. All materials needed for construction will come from existing commercial sources with stockpiles and reserves beyond the requirements of the project.

Construction of the proposed facility should not affect the physiography, geology, or seismicity of Southern California or the Los Angeles Harbor area.

Operation of the proposed facilities will not affect the geology or seismicity of Southern California or the Los Angeles Harbor area. The soil will not be affected nor will any mineral or water resources of the area be depleted as a result of this project.

Water Resources

Dewatering of the surficial soils will be necessary for construction in excavations. A field investigation program is planned to identify the chemical quality of the groundwater to be pumped and the hydraulic properties of the water-bearing sediments. The results of these studies will be used to predict offsite effects of dewatering and to determine if the water will require treatment prior to discharge in the harbor.

There are no freshwater wells in use on Terminal Island; therefore, there should be no construction impact on potable water sources.

There should be no impact on fresh water resources during plant operation. Sanitary wastes will be discharged to the municipal sewer system. Fresh water for domestic use will be obtained from the local municipal water system.

Effects of the proposed project on the physical marine environment of Los Angeles Harbor will result from the marine facility construction, and from discharges of groundwater and hydrostatic test water into the harbor. More significant effects will be on the biota, as discussed in the section on wildlife.

The Port of Los Angeles plans to dredge a navigation channel, turning basin, and berthing area to a depth of 45 feet below mean lower low water (MLLW) in order to provide LNG ship access to the south side of Terminal Island. The dredging required for this project will be conducted as a part of an overall plan for harbor development, which will involve dredging and disposal of spoil behind dikes to create extensive areas of landfill.

Investigations are now being conducted by the Port of Los Angeles to evaluate the environmental impacts of dredging and landfill operations. The potential impacts on water quality will be determined as a result of these investigations.

The U.S. Army Corps of Engineers is conducting physical modeling studies at the Waterways Experiment Station in Vicksburg, Mississippi, to determine the effects on oceanographic conditions of the Port of Los Angeles plan for harbor development. The first results of these studies could be available as early as March, 1975.

Two parallel, 10-foot diameter, seawater return lines will extend from the LNG vaporization plant east to the Los Angeles-Long Beach border, and then south across the harbor to the breakwater. Present plans call for the lines to be constructed over the top of the breakwater, and extend seaward to the point of discharge.

There are two alternate methods of construction of these lines. The first method would involve the excavation of a trench into the existing harbor bottom to protect the lines from possible damage by ship anchors. This would involve dredging and backfilling. The second method assumes the existence of a future landfill along the proposed route, and conventional dry land construction techniques would be employed.

An investigation will be conducted to analyze sediments from the harbor bottom along the proposed route, and a complete assessment of potential impacts will be submitted as an addendum to this report. If conventional dry-land construction techniques are used, there will be no impacts on the marine environment, except those noted in the following section.

Removal of water from LNG tank excavations and onshore pipe trenches will be required to provide dry working conditions during construction. This water probably will have a composition similar to seawater due to the close proximity of the site to the harbor, and the hydrologic nature of the subsurface soils. Direct discharge of this water to the harbor should not have a significant impact on harbor water quality in the vicinity of the discharge. Any discharge of groundwater to the harbor during construction of this project will meet discharge requirements specified by the California Regional Water Quality Control Board--Los Angeles Region.

Approximately 11.5 million gallons of fresh water will be utilized for hydrostatic testing of each LNG storage tank. If scheduling permits, the same water will be used for testing each of the tanks. Discharge of this water should have an insignificant impact on salinity because the harbor ordinarily receives a variety of low salinity discharges, including storm water runoff.

Construction of the LNG storage tanks will require excavation through existing hydraulic fill and rubble. This excavated material either will be used to fill other areas of the site during construction, or transported to approved disposal sites. No significant impacts are anticipated.

Dewatering of the excavations will be required to provide dry working conditions during construction. Present plans call for discharge of this water into the harbor. It is anticipated that the water will be essentially seawater due to the close proximity of the site to the harbor. Therefore, there should be no significant adverse impacts.

Sanitary facilities required during construction will consist of portable chemical toilets. Trash will be collected and disposed of at existing sanitary landfill sties. No significant impacts on the environment will occur.

Approximately 11.5 million gallons of fresh water will be used for hydrostatic testing of the LNG storage tank. If scheduling permits, this water will be reused for the testing of each tank. This water will be discharged to the ocean upon completion of the testing. Provided that the water is discharged to the ocean at a relatively slow rate, comparable to normal storm water runoff, impact on the marine environment should be negligible.

Base-load vaporization will occur in seawater-heated vaporizers that will utilize 600,000 gallons per minute (gpm) of harbor seawater during normal operations. The seawater will be transferred by pipeline from Slip 302 to the LNG vaporization plant, where it will be used as a heat source for vaporization. Cooled seawater will then be transferred by pipeline to the open ocean beyond the harbor breakwater. The effluent cooled seawater will be 12°F below ambient at the point of discharge.

During the early operating period when LNG receipts are less than the projected 4,000 MMcfd rate, seawater may be taken from points other than Slip 302 and the discharge may be within the harbor rather than the open sea. At each stage of development, the seawater circulation and its discharge temperature will be such that the impact on the environment will be within acceptable limits.

Studies are in progress to determine the optimum locations and methods of intake and discharge to minimize adverse effects on harbor currents, and temperatures inside and outside the harbor. Computer techniques are being used to predict the jet path and dilution of temperature in the cooled-water plume. Past applications of this computer model to cooled-water discharge problems have shown that it is often practical to discharge the cooled water at or near the bottom, and jet the effluent upward at an angle. The proper combinations of discharge velocity, jet angle, and port diameter could result in schemes that will produce optimum mixing and would limit the effects of temperature depression to a relatively small area.

A detoxifiable biocide, Acrolein, will be added at a rate of 0.4 to 0.8 part per million for 4 to 6 hours per day to inhibit growth of fouling organisms in the seawater vaporization system. The biocide will be effectively neutralized prior to discharge by the addition of sodium bisulfite resulting in a nonreactive, stable salt that is not detrimental to water quality.

The LNG facility will produce approximately 4,500 gallons per day of sewage when in full operation. This sewage will be disposed of through the Los Angeles municipal sewer system. The additional sewage load will represent an insignificant increase in wastes discharged into the system.

Sanitary and other liquid wastes from LNG ships will be processed onboard. No wastes will be discharged from the ships while they are in the terminal.

The only industrial waste to be discharged to the marine environment from the facility will be about 70 gpm of pH 5.5 water derived from the gas-fired vaporizers periodically used for peaking. These vaporizers will be used for up to an estimated 480 hours per year under normal operating conditions. The water will be diluted by mixing with the 600,000 gpm base-load waters and discharged to the ocean. This discharge will have a negligible impact on ocean water quality.

Seawater will be required to remove the latent heat content of the exhaust steam in the LNG ships' condensers.

Preliminary calculations for the 165,000-cubic-meter ships indicate that about 60,000 gpm of seawater at 6°F above ambient will be discharged while ships are underway. While berthed, the same volume of water will be discharged, but it will be only 2°F above ambient. The lesser temperature rise while ships are berthed is due to the reduced power requirements of the ships. The effects of this discharge do not appear to be significant; however, a complete evaluation will be made when ship design specifications are finalized.

There will be an LNG containment system under the unloading facilities; however, should there be a spill, its impact on the marine water quality is expected to be small to negligible. Dispersion of LNG into the water column is expected to be slight. Since the density of LNG (approximately 26 lbs/ft^3) is low compared to water, buoyant forces will tend to prevent mixing into subsurface waters. Furthermore, the small droplets of LNG that are most likely to enter the water column will be vaporized rapidly into much larger and lighter bubbles of natural gas, which will easily move upward to the surface.

Of potentially far greater impact on the physiochemical properties of the seawater than an LNG spill is the possible effect of a fuel oil spill. Bunker C fuel oil and diesel oil will be transferred to the facility for subsequent bunkering of the LNG ships. Fuel oil will be delivered to ships as needed from a land-based tank supplied by pipeline. The Bunker C requirement is not known and will depend upon requirements of the ships using the terminal. Diesel oil for emergency use will be stored in a 5,000-barrel tank.

Expected physical and water quality effects associated with a fuel oil spill are the reduction of sunlight into marine waters (not likely to occur with a diesel oil spill) that is necessary for phytoplankton photosynthesis, and the reduction of the dissolved oxygen content beneath an oil slick. Also, the lighter fractions of petroleum compounds may go into solution in the water column. Some of these lighter hydrocarbons are toxic to marine life.

The first two effects cited above were based upon observations made in enclosed water areas with little wind, wave and current circulation, or during extremely large crude oil spills. Since the project site is located on an open coast with considerable wind, wave and current action, these adverse effects are not likely to occur.

In addition, small discharges of materials incidental to construction and maintenance operations, such as paint, solvents, and lubricating oils, will undoubtedly occur. Because of the very small quantities used and the infrequency of the spills, however, such incidents are not expected to affect significantly the quality of the marine waters near the proposed site.

Approximately 4,500 gallons per day of sanitary wastes will be produced during operation of the LNG facilities. The wastes will be discharged into the existing municipal sewer system for treatment. This relatively small volume should have no significant impacts on the existing municipal sewage system.

Sanitary and other wastes from the LNG ships will be processed onboard. No waste materials will be discharged into the harbor.

Vegetation, Wildlife and Ecological Considerations

The site consists of approximately 43 acres of undeveloped open space of barren fill/spoils and weedy vegetation, 25 acres of presently paved automobile storage area, and 25 acres of existing buildings and associated landscaping on a naval facility. About 10 acres of new fill will replace harbor waters in the southeastern corner of the property. Construction of the proposed facilities will eliminate vegetation and wildlife habitat on about 59 acres of the 103-acre property.

Since vegetation on the property consists of isolated individuals of coastal strand species, weedy vegetation, and landscaping, its removal is not considered to be a significant adverse impact. The site will be relandscaped when construction is completed and weedy vegetation will revegetate unused portions of the property.

Animal variety and abundance on the property is low. During construction, wildlife habitat on the property will be eliminated, and resident populations of small mammals, reptiles, and amphibians (if present) will be temporarily reduced. Bird use of the affected and adjacent areas probably will be reduced during construction.

After construction, landscaping planted on the site and weedy vegetation on unused portions of the property will be reinhabited by wildlife, especially birds. Open space on the property probably will be sufficient to provide resting areas for gulls, terns, and other birds presently using the barren fill/spoils. Therefore, construction of the facilities will not have long-term significant adverse effects on the fauna of the property or region.

At present, the property is apparently an unsuitable nesting habitat for the California least tern, an endangered species. Therefore, construction is not expected to affect use of the area by the least tern. The activity of these terns on Terminal Island is being monitored by the California Department of Fish and Game. Other rare, endangered, and fully protected faunal species in the area are not expected to be significantly impacted. No rare or endangered plant species will be significantly affected.

If required, acquisition of fill materials from off-property terrestrial borrow sites could necessitate the removal of vegetation and wildlife habitat from those borrow areas. This could produce adverse environmental effects depending on the type and quantity of vegetation removed.

The major construction impact on the marine biota will result from the dredging of the berthing area, turning basin, and ship channel. The planned dredging and landfill for this project conform to the Port of Los Angeles Plan for overall harbor development and the impacts from the entire plan will be addressed by the Los Angeles Harbor Department.

Minor construction-related impacts on the marine biota will include those associated with pier construction, runoff from the land site, discharge of hydrostatic test water from the storage tanks, and the dredging associated with the outfall construction.

Pier construction will involve pile placement in the newly dredged berthing area. The effects of this construction will be on a disturbed sedimentary biota. Pile placement will produce minor turbidity and noise, which will delay the reestablishment of portions of the benthic invertebrate and fish faunas. It will also result in the permanent exchange of flat sedimentary bottom (under the piles) with a greater area of solid, high vertical-relief substrate (the sides of the piles). The change to solid substrate could result in a more varied biota, and the high relief could result in greater concentrations of some species of fish. The net effect of pier construction should be a long-term minor benefit.

The major impact of construction on the harbor biota will be due to the dredging of the ship channel and turning basin between Slip 302 and a point near the Los Angeles Harbor breakwater entrance. This will involve removal of sediment and organisms. The loss of organisms will be temporary because the newly exposed substrate will be recolonized, and there is no reason to believe that the biomass density of the recolonizing animals will differ significantly from that prior to dredging. In fact, the resulting area will be greater than the existing area, producing a greater total biomass in the long term.

The removal of sediment laden with municipally derived waste products (heavy metals, PCBs, and pesticides) is another benefit realized by eliminating from the ecosystem toxic substances that can be concentrated through the food web or can inhibit in situ biomass production via sublethal effects on reproduction and growth.

The increased depth of the new ship channel might cause replacement of some of the members of the original faunal assemblage by species more capable of living at the somewhat reduced temperatures of this greater depth, but this should be minor. Comparing faunal lists from benthic stations near 45-foot depths with stations in shallower water reveals little change in species. The likelihood that these warmer water species play an important part in the harbor food web is small, because they tend to be rare and occur in low numbers where found.

Turbidity resulting from suspension of sediments during removal will be another immediate effect of the dredging. Attempts will be made to minimize turbidity, but some resuspension is inevitable. The effects due to sediment resuspension are all temporary, ceasing soon after completion of the dredging. One effect will be an increase in turbidity that may depress primary productivity by lowering light levels. This will tend to counteract a second effect: the enhancement of productivity through the release of nutrients (formerly buried in the sediments) being made available to bacterial and phytoplankton populations. An increased surface area for bacterial colonization and increased oxygen availability should result in increased bacterial degradation of large organic molecules and the release of nutrients available to phytoplankton. In semiclosed systems, the end result of this is exhaustion of the nutrient supply by phytoplankton, subsequent die-off to the original standing stock levels, and an increased supply of new organic matter to the sediment. This effect should cause a temporary increase of bacterial growth and a reduction of local oxygen concentrations, perhaps to the point of causing oxygen deprivation. This is unlikely however, due to the open nature of the outer harbor system and the probably counteraction of that potential increase in productivity by the increased turbidity.

A third effect, the addition of formerly buried toxins to the food web, is of greater concern. Work in progress indicates some sublethal effects of these toxins on members of the harbor biota, although there is as yet no evidence for massive mortality. However, to minimize the potential damage to the biota by toxins, every effort will be made to reduce the resuspension of sediments from dredging. The dredge spoils will be used for landfill.

Construction of the intake and discharge conduits may cause some addition to the water of excavated soils from the construction site, slightly increasing turbidity at the head of the ship channel. If this occurs the effect would be temporary and insignificant.

As presently planned, the outfall will extend across new landfill (discussed in the following section), and then across the harbor bottom to the breakwater along the Los Angeles-Long Beach boundary. The outfall conduit will then traverse the breakwater and terminate outside the breakwater on the bottom of San Pedro Bay. The two 10-foot-diameter outfall conduits will be buried in the harbor bottom by dredging and backfill, unless the landfill for the Port of Los Angeles Plan for this particular area has been completed. This dredging will eliminate the benthic biota and generate turbidity along the dredged path. However, after the construction and burial of the pipeline, a similar fauna to that previously present should reestablish itself. Outfall construction beyond the breakwater into San Pedro Bay probably will bring about effects similar to those resulting from outfall burial in the harbor bottom. The effects of this dredging will be much less than that for the berthing area, turning basin and ship channel.

Sediment removed during the dredging of the harbor bottom will be used as landfill, permanently burying that part of the harbor and destroying it as a marine habitat.

During rains, runoff from the construction site and the landfill will add material to the water, causing an increased turbidity adjacent to the construction areas, and could carry toxicants into the harbor. These effects should be temporary and insignificant.

The solid substrate of the containment dike around the landfill will add vertical relief, shelter and new rocky habitat. This permanent addition will provide some exchange for the loss of sedimentary habitat under the landfill. The variety of biota and the variety and standing stocks of fish will both be greater in the new rocky habitat than on the existing, poor quality, sedimentary habitat.

Approximately 11.5 million gallons of hydrostatic test water will be discharged from the site into the harbor. Discharge will comply with all applicable requirements.

Emissions from the facilities will comply with appropriate emission regulations. The percentage increase above the baseline ambient concentration of pollutants in the area appears to be small. Therefore, there is little likelihood that emissions from this facility will have significant effects on existent vegetation damage patterns for fauna in the region.

Regular or cyclic noise from facility operations will not be significantly above local ambient levels. Noise is not expected to have significant detrimental effect on the fauna of the area, since habituation probably would occur in most resident species.

Operation of the LNG ships will incrementally increase the possibility that foreign species of plants and animals, including insects and disease, might be introduced into the Los Angeles Harbor area. Unless an introduction were a particularly noxious weed, disease, or other pest, it would be of minor significance.

Operation and maintenance of the LNG facilities are not expected to have any significant impact on rare, endangered, or fully protected faunal species.

Operational impacts on marine biology will result from entrainment and impingement of plankton and nekton in the seawater vaporization system, contact with the cooled-water plume in the discharge area, and ships' cooling water discharges and ballast water uptake.

The intake for the seawater vaporization system will be at the head of the ship slip. Flow rate will be about 600,000 gpm. An average of the values presented for productivity at the nearest station is $13 mgC/hr/m^3$. If 100 percent mortality is assumed for mechanical damage, thermal shock and biocide effects and one-half day is required to "repopulate" each parcel of returned water, then about 200 tons per year of biomass loss can be expected from effects of entrainment on primary productivity. If 3 trophic levels are inserted between the phytoplankton and the "average" harvestable fish, the result is a loss of about 400 pounds of fish biomass per year.

The impact of entrainment on most nekton will be prevented or reduced by the use of screens and/or fish return systems. Effects are dependent upon screen size, velocity at the screens and design of the return system. The most important commercial fish resource in the harbor at present is the anchovy.

If the volume of the outer harbor is about 10^{10} cubic feet (assuming an area of about 12 square miles and an average depth of 30 feet), then the system will entrain about 1 percent of the outer harbor's volume each day. The tidal exchange replaces about 10 percent of the outer harbor volume with each tidal cycle.

The loss of biomass, productivity, and larval potential will be added to the discharge area in the form of new food supply. The net effects of entrainment from the seawater vaporization system will, therefore, be a long-term loss of standing stock, productivity, and larval potential from the outer harbor and a long-term gain of food source in the outfall area outside the harbor.

As presently designed, the outfall will discharge water at the bottom of San Pedro Bay that is 12°F (6.7°C) cooler than the receiving water. Comparison, at corresponding times for 1971-1973 (Soule and Oguri, 1974b), of monthly surface temperatures in Los Angeles Harbor and the San Pedro Bay subsurface temperature at 52.5 feet shows that June is the only time of year when the difference between these 2 temperatures equals or exceeds the 12°F differential that will result from vaporization of the gas. At these times, the discharge will be at or near the ambient temperatures of the discharge area. In January, the temperature difference from those data is at most 1.1°F (0.6°C), and can be zero.

The fauna of the area are primarily temperate to cool-temperate (Dames and Moore, 1974a). Temperatures below 40°F are regularly experienced only in subarctic and arctic seas and are obviously below the tolerance level of virtually every component of the general area fauna, none of which are known to range north of the Gulf of Alaska. Subtracting 12°F from the coldest surface temperature (50.2°F [10.1°C]) recorded inside the harbor for that period produces a temperature of 38.2°F, approximately 8°F colder than the coldest bottom temperature recorded outside the breakwater for that period. This temperature, according to recent studies on some Los Angeles Harbor species, is enough to depress feeding.

Regardless of the areal extent of the nonambient isotherms around the outfall, the lower temperature will cause some shift in the biotic composition of the plume area. Marginal warm-affinity species will be replaced by cooler water species and marginal cool-affinity species will survive through longer periods of the year. Reduction or loss of breeding period by species whose spawning behavior is keyed by higher temperatures will be offset by extended breeding periods for cool-adapted breeders. In an exposed coastal area such as the San Pedro Channel, the extent of the long-term impact from the cooled discharge should be limited.

Acrolein, a detoxifiable biocide, will be injected into the intake water in order to kill potential fouling organisms. The acrolein will be neutralized before discharge by the addition of sodium bisulfite and should, therefore, have no significant effect on the biota in the recurring waters. A system to stop and neutralize the acrolein input in the event of failure of the neutralizer addition system will be provided.

The LNG ships, while unloading, will discharge elevated-temperature cooling water. This water would be discharged into the slip and from there into the seawater heating system.

As presently planned, 2 ships will berth daily, requiring ballast water. The amount of plankton lost with this water will depend on the size of ship but is expected to be negligible.

All LNG ships will carry Bunker C oil for their return trips. This will be supplied to the ships, while berthed, through a pipeline and loading arm. The qualitative impacts on marine life from Bunker C spills is discussed as follows.

A spill of Bunker C oil in or outside the harbor will cause some stress to the pelagic environment because those organisms, primarily plankton, exposed to the fresh spill probably will receive lethal dosages of the toxic fractions. The areas of shoreline, including the breakwater, coated by the oil will lose a substantial portion of the attached fauna due to suffocation, but removal of the oil by natural processes should be followed by recolonization. Damage to bird populations (especially to birds that commonly rest or feed in the water such as gulls, cormorants, loons and grebes) would be longer lasting since their recruitment rates are slower than for most fish, invertebrate or algal species. Contingency plans for containment of the spill and removal of the oil from the water surface will reduce the areal extent of potential damage.

Economic and Sociological Factors

The construction program is to be carried out over an approximate 39-month period. Activity is expected to peak during the 8th and 9th quarters when the work force will reach 1,500 (excludes indirect administrative, management, and technical personnel onsite during construction) craft and supervisory personnel on the job site. These manpower needs can be met from among the 146,00 construction workers in the Los Angeles-Orange County labor pool; the maximum estimated requirement for 1,500 personnel represents only about 1 percent of that labor force.

In addition to the foregoing needs, onsite technical and administrative personnel also will be required. The actual numbers of these support personnel are not yet known, but experience indicates they will represent about 10 to 15 percent of the craft and direct supervisory labor force. All the support personnel are expected to come from the metropolitan area labor pool and will not add to the employment base.

About $39 million in direct wages (1974 dollars) will enter the Los Angeles-Orange County metropolitan area economy during the construction period. This sum represents an average of $1 million per month. On the basis of 1972 data, the most current available, this represents less than 1 percent of the annual contract construction wages within the metropolitan area; that is, $307.566 million and $60.223 million for Los Angeles and Orange Counties, respectively.

On the assumption that the construction manpower requirements will be met from the labor pool available in Los Angeles and Orange Counties, the construction phase of the project is not expected to affect the demographic characteristics of the surrounding communities of San Pedro, Wilmington, and Long Beach. It is unlikely that the construction effort will create demands for permanent housing in the Los Angeles Harbor area.

However, there may be a project-related requirement for more transient rental units because such facilities will not be provided onsite. This demand would be created by workers who might be recruited from outside the Los Angeles-Orange County area or by workers who may live in the outlying parts of the metropolitan area and prefer to commute to the site on a weekly basis.

While it is not possible to predict the exact number of employees who would require rental housing, it may be assumed that they will comprise only a small minority of the total work force. The demand, therefore, probably could be met by existing housing.

In summary, the construction phase of the project is expected to have an insignificant impact on either permanent or rental housing.

There are firefighting facilities at 5 locations on Terminal Island, all within 1-1/2 miles of the project site. No additional equipment will be required during the construction phase. Control and direction of vehicular traffic near the site will be handled by privately employed traffic patrols and flagmen. No added public police services will be needed.

All construction methods and equipment use will conform to appropriate codes and standards. Further, protective equipment and items such as onsite water hydrants will be installed.

An emergency communications system also will be provided. The impact of the construction effort on public protective services will be insignificant. The data indicate a potential revenue to the City of Los Angeles amounting to $734,000.

Another source of income to the city and local agencies are the property (ad valorem) taxes on the partially completed facilities over the construction period. Other revenues would accrue from purchases of construction materials from local sources.

The project site includes a vacant landfill, a built-up section of the adjoining U.S. Naval Base and part of an open, paved, automobile storage area. The facilities at the Naval Base will need to be relocated or torn down when the lease for that section expires.

The proposed project site is in an industrial area with little visual appeal. The construction effort will be visible from both land and sea, but may attract only passing notice against the existing industrial background.

Approximately 90 personnel will be required to operate, maintain and administer the LNG facility. These people will come mainly from the Los Angeles-Orange County metropolitan area. The estimated gross annual payroll of $1.8 million, amounting to a disposable income of $1.37 million, will be spent principally in the metropolitan area. This represents an aggregate direct impact upon the economic base of approximately $27 million over a 20-year economic life of the project.

Because the 90 operating personnel will come from the Los Angeles-Orange County metropolitan area, the impact on housing will be insignificant.

There are fire fighting facilities at 5 locations on Terminal Island, all within 1-1/2 miles of the project site. No additional equipment will be required during plant operation. No added public police services will be needed.

Because most operating personnel will come from nearby metropolitan areas, there will be no significant impact on local school facilities.

Within 10 miles of the plant site there are at least 12 hospitals that maintain emergency service. No additional bed capacity will be required.

Water supply requirements for the project will be about 7,650 gpd. A 12-inch waterline presently is located within the right-of-way on Terminal Way toward Ferry Street. An 8.5-inch waterline is located south from Terminal Way within the right-of-way of Ferry Street.

Approximately 4,500 gpd of sewage will be discharged to the existing sewage system. A sewage treatment plant presently is located on the northwest corner of Terminal Way and Ferry Street. There are plans to expand this facility on an adjacent lot to the west. The capacity of these utilities should be sufficient to meet the needs of the plant.

Power requirements for operation of the LNG plant probably will be met by the Los Angeles Department of Water and Power.

The principal beneficial impact of the facility upon the area would be derived from ad valorem (property) taxes on the completed facility. With a total estimated value of $350 million upon completion, the facility will add approximately $11.3 million annually to the revenue of the city, county, districts, and agencies sharing the tax dollar. The new property tax revenue to the city of Los Angeles ($2,400,000) will represent about 1 percent of the total property tax revenue to the city during the fiscal year 1973-74.

The proposed project site is vacant landfill. There is no requirement for the relocation of residences or of businesses.

Operation of the LNG facility will not interrupt access to any public facilities or recreational areas on Terminal Island.

Land Use

The proposed Los Angeles Harbor LNG plant site currently is zoned for heavy industrial use by the City of Los Angeles. Construction of the proposed project will commit about 59 acres of the 103-acre site to industrial use. This will not conflict with existing land uses in the area. No significant construction related land-use impacts will result from construction of the proposed facilities on Terminal Island.

The marine facilities will be located at Slip 302 adjacent to the proposed plant site. The Los Angeles Harbor Department will build the berthing facilities on city-owned property. During construction, the portion of the seawall and shoreline along the southeastern and southern boundaries of the site will be closed to the public. Public access to the open site area has not been encouraged previously, although the area is used for limited recreational activity, notably fishing and some boating. Because of the existence of other developed recreational facilities nearby, closure of the plant site area for recreation involves a negligible impact.

The LNG transfer system will be constructed on leased property and will not interfere with other land uses in the area.

Two 10-foot diameter seawater pipelines will be constructed between Slip 302 and the LNG plant. These lines will traverse leased property and will not affect land uses on adjacent parcels.

Construction plans for two parallel 10-foot diameter seawater discharge lines have not been finalized. Present plans call for the lines to extend from the LNG plant site east to the Los Angeles-Long Beach border, then south to beyond the harbor breakwater. Present plans call for dredging a channel along the existing harbor bottom for burial of the lines. The lines will then be constructed over the top of the harbor breakwater, and extend along the bottom outside the harbor to the point of discharge. If the Port of Los Angeles plans for landfilling a major portion of the harbor are complete before construction of this project, the seawater lines will be buried below the surface of the landfill.

The labor force required for the construction effort will be drawn from the existing labor pool in Los Angeles and Orange Counties. Local housing requirements of workers will be minimal and temporary. Any secondary land-use requirements generated by the project, such as for housing and commercial services, will be insignificant.

Road access to the construction site presently is along Ferry Street and Terminal Way. Ferry Street is a 2-lane paved road to its intersection with Terminal Way, also a 2-lane paved road. The intersection of Terminal Way and Ferry Street is at the northwest corner of the proposed construction site. Traffic on these 2 roads is heaviest during the morning and evening worker-commuting periods. At other times, they are only lightly utilized.

Road access to Terminal Island is provided by the Vincent Thomas Bridge on the west, the Cerritos Channel crossing on the north, and the Gerald Desmond Bridge on the east. The Vincent Thomas Bridge had an average daily traffic count of 21,700 vehicles in 1973. Peak-hour traffic averaged 2,600 vehicles during that same year. In May, 1972, the average daily traffic on the Terminal Island Freeway crossing over the Cerritos Channel was 10,579 vehicles northbound at the Anaheim Street ramp and 11,453 vehicles southbound at the same location. Average daily traffic over the Gerald Desmond Bridge was 31,000 in July, 1972.

Under ideal conditions a maximum of 2,000 passenger vehicles will travel each lane of a 2-lane, 2-way road each hour. In terms of the 3 bridges providing access to Terminal Island, this means that a maximum of 4,000 passenger cars could cross each of them in 1 direction in 1 hour. Maximum daily capacity (per bridge in one direction) would be 96,000 passenger cars. On that basis and from actual usage data summarized below, the excess capacity for each bridge over a 24-hour period is considerable. However, the average daily traffic figures for each of the 3 bridges will be concentrated at peak commuter periods.

	Average Daily Traffic	24-Hour Capacity	Excess Capacity
Vincent Thomas Bridge	21,000	192,000	170,300
Terminal Island Freeway	22,032	192,000	170,968
Gerald Desmond Bridge	31,000	192,000	161,000

Peak-hour traffic was recorded for the Vincent Thomas Bridge only. Even this was considerably below computed capacity on an hourly basis; that is, 8,000 passenger cars per hour.

Other major arterials in the area carry heavy traffic. This is particularly true of the San Diego Freeway and its north-south feeder freeways. Data indicate that traffic volumes increase progressively as one approaches the San Diego Freeway from the harbor. Terminal Island traffic is relatively light; the only possible areas of congestion that might occur during construction of the LNG plant are at the bridges which connect Terminal Island to the mainland, and along Seaside Avenue, the major island road connecting the bridges.

Automobile and truck traffic to and from the construction site will consist predominantly of the work force and concrete trucks. During the period of lowest employment, the labor force will add about 285 vehicles per day to the traffic flow; this will increase to about 2,143 vehicles per day for the peak employment period (vehicles per day is equal to the number of employees times two trips per day times 5 days per week, the entire numerator divided by 7 days per week). Traffic should be dispersed over all 3 bridges so that the increase in average daily traffic will be only about 3 percent on each bridge.

The impact of construction personnel on road traffic will be greatest during the rush hours. However, total traffic on the bridges still will be less than half the capacity available.

The other significant construction-generated traffic is that of concrete trucks. About 7,800 round trips will be required for concrete deliveries, assuming a concrete requirement of 70,000 cubic yards, delivered in 9-cubic yard capacity trucks. With the exception of the continuous pour that must be made for the tank dike walls, this traffic could be scheduled to avoid peak-hour traffic. The greatest impact of the truck traffic would occur over a 5-day period during which the dike walls for each tank are poured. This continuous pour will require some concrete trucks to enter and leave the island during rush-hour traffic, but proper routing of concrete trucks over all three bridges will minimize that traffic impact.

In summary, the impact of construction traffic on Terminal Island will be moderate. The most significant impact will occur at the peak morning and evening rush hours during those times when concrete trucks will be required for the continuous pour.

A railroad spur could be constructed from the existing Union Pacific System on the north side of Ocean Avenue to transport nickel-steel plating, piping, and heavy machinery to the site. Between 2,400 and 3,158 railroad carloads will be required to transport steel plating to the site. Since the rail network already in existence handles industrial goods, no adverse effect upon the railroad bed is anticipated. The movement of materials would be scheduled to minimize any interference with vehicular traffic movement on Seaside and Ocean Avenues. However, there will be a significant impact upon rail traffic within the Terminal Island area.

During construction of the LNG ship channel, dredging equipment and various support vessels will cause temporary disruption of marine traffic in the construction areas. The Port of Los Angeles plans to dredge the required channel as a part of its overall plan for harbor development.

The operation of the proposed facilities should not have an adverse effect on existing land use on Terminal Island or in the greater Los Angeles Harbor area, as most of the area is zoned for industrial uses, including the site. It is anticipated that undeveloped land in and around the site area eventually will be restricted to marine and marine-oriented industrial uses and activities only. This is confirmed in the Los Angeles Harbor Department's long-range development plan for the harbor area. The plan calls for the creation of filled land in the outer harbor between the present seaward line of Terminal Island (that is, the location of the LNG site) and the first detached breakwater to provide additional land for marine-related industrial uses. The LNG facility proposed for the site complies with these plans, although its construction could restrict the city's flexibility to attach certain types of industry to adjacent properties.

Ninety people will be employed at the facilities. The additional automobile traffic (about 129 vehicle trips) generated by this labor force will have insignificant effect on local roads and highways (calculations for increases in total vehicle trips per day due to the plant labor force were based on the following formula: Total vehicle trips per day = (number of employees) (2 trips per day) (5 working days) - (7 weekdays).

It is estimated that the maximum increase over baseline conditions in daily traffic on Seaside Avenue and the three island bridges (more than 31,000 vehicle trips) will amount to less than 1 percent. Heavy truck traffic to and from the site will be irregular and minimal, and should have little effect upon traffic in the area.

LNG ship traffic will vary with the capacity of the ships that are used. At the application rate, there should be 565 arrivals per year, using 125,000-cubic meter capacity ships, and 425 arrivals per year, using 165,000-cubic meter ships. Such arrival rates will result in a 13 to 18 percent increase in harbor ship traffic compared to the 3,169 ship arrivals in fiscal year 1973.

Plant operations are not expected to require rail service nor interfere with local air traffic.

Paleontological, Archeological, and Historical Resources

There are indications that villages of the Gabrielino Indians were in the general area. It is assumed, however, that all archeological evidence has since been obliterated by dredging and filling operations associated with the development of the harbor and by subsequent construction. Therefore, any construction activity at the site should have no additional adverse effect. However, any archeological discovery during site preparation or construction will be evaluated by archeologists before further disturbance or removal. Complete instructions for archeological preservation are contained in federal statutes pertaining to salvage archeology, which provide for the preservation of historic American sites, buildings, objects, and antiquities of national significance.

No historic sites or structures are known to exist within or immediately adjacent to the Terminal Island site. The area has been filled and/or otherwise developed by man for several decades; thus, neither preparation of the site nor construction of the proposed facilities should have an adverse effect on historic sites or structures. This assessment is made on the basis of archival research.

No historic sites or structures, or archeological sites, will be affected by operation of the LNG facilities.

Recreational and Esthetic Resources

The construction and operation of the proposed facilities should not have a significant impact upon the recreational and esthetic resources of the project area.

Air Quality

Construction of the Los Angeles Harbor vaporization facility will result in minimal impact on the existing air quality of the area. During initial site preparation activities, brush and debris will be hauled away for suitable disposal and will, thus, cause no air pollution by smoke.

Movement of vehicular traffic, construction equipment, and other construction activities may cause localized short-term particulate loadings in the atmosphere in the vicinity of the site. The particulate loading may exceed regulatory limits at times, particularly during prolonged periods of dry, warm weather and strong inversions that Los Angeles experiences during the summer months. Amelioration or abatement of this problem will be accomplished by a program of wetting, paving, or oiling construction roads and restricting traffic, when possible, to these roadways. Additionally, any areas to be graded where significant amounts of earth moving are required will be wetted, where possible, to reduce dust.

During operation, the proposed facility would vaporize approximately 4,000 MMcfd of high-purity natural gas. As a result, some contaminants will be emitted into the atmosphere. The primary pollutants of greatest concern are found to be nitrogen dioxide and sulfur dioxide. Within a few kilometers of the plant, operations may be expected to increase the number of exceedances of the peak 1-hour standard for NO_2 and, possibly, cause a few exceedances of the 1-hour SO_2 standard.

Natural gas will be burned to supply heat for the several processes involved in vaporization. The natural gas will have fairly high purity. In comparison with other fossil fuel energy sources, the combustion of this mixture will minimize the emission of potentially harmful contaminants.

During operation, the annual average concentrations of nitrogen dioxide emissions from the proposed facilities would be less than 0.001 ppm, even with all sources operating full time. Thus, the annual average effect of nitrogen dioxide emission is less than 2 percent of the national standard (0.05 ppm). The present annual average at Los Angeles Harbor is 0.07 ppm, which already violates the standard, and the additional impact on this already poor air quality is only 1 percent.

The annual average sulfur dioxide concentrations were computed under a worst-case assumption that there was an average of 1 ship moored at all times with boilers operating at full capacity. These conservative assumptions give only an 8-microgram-per-cubic-meter annual average concentration, which is insignificant compared to the standard of 80 micrograms per cubic meter. The baseline annual average concentration of the area is 0.025 ppm which, added to the concentration 0.003 from plant emissions, still is not sufficient to exceed State of California standards.

Environmental Noise

Creation of some additional noise is inevitable during construction. Most of the noise will come from heavy-duty excavation equipment used to erect buildings and storage tanks. Operation of construction equipment will comply with existing noise ordinances of the City of Los Angeles. Noise from these sources will be of short term in nature and will terminate when construction is complete.

Because construction will be accomplished during the day, construction noise impact for this project will be insignificant when compared to the normal daytime noise environment in Los Angeles Harbor and nearby industrial areas.

Periodic checks will be conducted to insure that the L_{50} levels in the community are not being severely affected. Little impact on the present noise environment is anticipated because most of the project work will be performed during the day. Careful selection of equipment, proper scheduling of construction, and the meeting of OSHA worker hearing protection requirements will minimize the noise impact from construction. Contractors will be made aware of the noise sensitive areas adjacent to the construction site. No blasting operations are anticipated.

During operation, the proposed LNG facility will be designed to meet a maximum allowable noise level (L_{50}) of 58 dBA at a distance of 1,000 feet from the site boundary and at a height of 5 feet above the ground plane. Studies have shown that, at this level, sporadic complaints can be expected from the community.

This criterion assumes that the noise produced by the plant will be broadband and continuous in nature, with no discernible pure tones present, and that the plant will operate on a 24-hour basis.

In the event that the character of the noise can meet two specific conditions, an alternate maximum allowable noise level (L_{50}) of 63.0 dBA applies. This alternate maximum level also applies at a distance of 1,000 feet from the plant property line. This criterion applies provided that (1) the noise produced by the plant is continuous in nature, and (2) the frequency spectrum shape of the noise produced is approximately that of the existing ambient, and free of any discrete tones. If the plant were to operate at its maximum allowable level, this could result in ambient levels (L50) of up to 3 dBA higher than presently experienced. However, if the two previously stated conditions are met, the new facility would blend into the ambient noise and could not be identified as a distinct noise source.

In the event that the proposed plant produces noise of an intermittent nature (that is, level changes of 3 dBA or more at a rate greater than once per hour) or that the frequency spectrum of the noise is audibly different in character from the background noise, the alternate criterion is not applicable.

The plant will not be generating and transmitting electrical power; thus, no radio interference signals should result from this operation.. The increase in harbor activities due to the LNG ship traffic will not raise the ambient noise levels.

Accidents and Catastrophes

The chief potential hazard of LNG is the flammability of its vapors when mixed with air within narrow confines.

LNG is stored in specially designed containers and conducted through piping that prevents air from contacting the LNG or its vapors. In this containment, LNG will not support combustion and cannot be ignited. In the event of a leak or spill, however, a flammable air and vapor mixture can result. When LNG is vaporized, a 5 to 15 percent methane concentration in air is typically flammable, but requires heating to a temperature of approximately 1,200°F for ignition to occur. If an ignition source is not present in the area of the 5 to 15 percent concentration, the LNG will complete its evaporation without burning. If ignited, the mixture may or may not burn back to its source.

LNG and its vapors are odorless and, therefore, undetectable by human olfactories. The cold vapor does produce a fog by condensing water vapor in the air, but this is not always a reliable leak indicator. Therefore, instruments calibrated to detect any leak before it becomes hazardous will be required. Odorant will be injected after vaporization of the LNG and before the gas is delivered into the gas transmission pipeline.

An analysis has been made to determine the maximum LNG vapor travel and thermal radiation hazard from the maximum credible spills and fires involving an LNG tank and dike system, and an unloading line containment system at the ship's dock. Specific calculations were made for hypothetical accidents involving (1) loss of the entire LNG storage tank roof, (2) complete draining of a full LNG tank into the high containment dike, and (3) maximum credible spill from the unloading lines at the ship's dock. The particular locations selected were those that might have either the greatest volume of LNG spilled or could have the most severe consequence from hypothetical accidents unless appropriate safety features were designed into the facility. No safety factor has been included in the calculations for any corrective action that would be taken either by plant personnel or automatic safety systems.

The calculations show that for the maximum credible spill at the tank and dike, under the worst conditions for vapor travel, the downwind concentrations will be less than 50 percent of the lower flammable limit 100 feet from the spill. These concentrations will be at the effective height of the source (the height of greatest downwind concentration--approximately 70 feet in this case) and will be within the limits of the plant property. For a maximum credible spill at the ship's dock, the downwind concentration at the effective height of the source (approximately 30 feet) should also be less than 50 percent of the lower flammable limit 100 feet from the spill. These vapor concentrations will decrease steadily with increased distance from the source.

The maximum thermal radiation hazard zone for unprotected exposed personnel should be 710 feet from the largest resulting fire at the tank and dike and 235 feet from the largest resulting LNG dock fire. The hazard zones for unprotected equipment and structures are much less. Objects within the limited thermal radiation hazard area, including adjacent LNG tanks, could be protected efficiently by spraying with water.

In conclusion, considering both the vapor plume and thermal radiation, the LNG facility and transfer system will be designed to safely contain the spill and control the effects of the maximum probably hypothetical accidents.

Spilled on water, LNG can produce crackling or pops. Low-energy vapor explosions have been observed during tests. The mechanism involved is directly related to an extremely low methane content of the LNG (less than 40 percent). In those low-methane LNG test cases when vapor explosions were produced, they have been shown to be low-energy physical phenomena confined to a thin LNG layer at the LNG-water interface with no resultant ignition.

The U.S. Coast Guard has authority for enforcing safety regulations on LNG ships. As specified by the U.S. Coast Guard Captain of the Port, the LNG ship will be underway near port only during periods of good visibility. Cargo handling operations will comply with U.S. Coast Guard regulations.

Statistically, a low percentage of collisions occurs at piers and berthing facilities. There is even less likelihood of a collision with a large vessel causing sufficient damage to result in a release of LNG. The dock used by the LNG ships at Los Angeles is close to the harbor entrance and will not require extensive travel along ship channels.

The LNG ships are equipped to dispose of boil-off gas by combustion in the boiler. If, for any reason, the boiler fuel system or land vapor return systems should be inoperative and unable to dispose of the boil-off gas, the ships also are equipped with vent stacks for emergency discharge. The point of discharge will be located at elevated positions and away from personnel areas and sources of ignition. In addition, the vent stack will be fitted with an automatic snuffer to extinguish any fire that may occur.

Facility design considerations and operator training procedures will be used to minimize impacts to safety. Should a dock spill occur, its most likely source would be at the connection between the unloading arm and the ship. Improper flange connecting or damage to the flange surfaces during repeated unloading/loading connection operations could result in this type of leakage. A swivel joint of the unloading arm might also leak. Scheduled inspection and maintenance will minimize these possibilities.

An interlock system will be designed into the operation that, under abnormal system conditions, will shut down pumps and transfer systems, and actuate appropriate alarms. An additional emergency shutdown system (ESS), activated by any one of several push-button stations onboard ship, on the dock, or ashore, will be provided.

Since spills will produce flammable vapor, it is important to keep sources of ignition away from the area. With proper precautions on the loading dock, the chance of a fire is small. In addition, strategically located fire and combustible vapor detection systems should give immediate warning of fire hazards and initiate protective action. A dry chemical fire extinguishing system will be provided at all strategic locations. A seawater pump and distribution system will be installed on the dock to provide for cooling of equipment during a fire. Gas detectors, air-breathing apparatus, and protective clothing also will be available on the dock.

Provisions for quickly halting cargo operations and disconnecting the unloading arms from the LNG ship will be provided. In addition, the mooring arrangements will be equipped with release hooks that can be operated by one individual. The LNG ship at the dock will always remain sufficiently manned for safe operation.

The LNG transfer system will consist of lines to deliver LNG to onshore storage tanks and lines for vapor return. The vapor line will return gas vapor to the ship to replace the volume of liquid unloaded during liquid transfer. So that gas is not released into the atmosphere, the vapor line also will transfer boil-off vapors from the ship to the storage area vapor system during ship standby.

Temperature sensors, located at regular intervals along the pipeline, will be monitored for indications of leakage. Remotely operated valves will be located at all vapor line exits from storage and at the ship unloading arm connections. In the event of a pipeline leak, shutoff valves would close, limiting the amount of LNG loss. Time delays on liquid valve closings will be used to eliminate fluid hammer effects that may result in undesirable dynamic loadings.

The phenomenon of rollover is an important consideration in the design of cryogenic storage tanks and the formulation of proper procedures to be used in operation. Rollover occurs when a portion of the contents of an LNG tank beneath the fluid surface acquires a density less than the liquid above it.

The less dense fluid rises and vaporizes rapidly during its ascent. The effects of this rollover phenomenon are increased dynamic loads on the tank structure and vapor evolution. This problem can be avoided by proper design and operating procedures. The condition of the tank contents will be monitored by temperature sensors. When fresh LNG is added to the tanks, adequate mixing of the contents will be ensured by controlling liquid flow into the top, bottom, or both as required by the operation.

Stations of the methane gas detection system will be installed throughout the storage terminal to detect leaks. Detectors will be located near pump and compressor stations, near vaporizers, and within the process area. The detectors will sound a warning if abnormal levels of methane are sensed. Operators will immediately verify the validity of the alarm by visual inspection and will shut down the equipment.

In addition to high standards of staff selection and training, and careful design for smooth operating flow, control devices will be designed into the facilities to minimize the hazards of possible operator error and to meet emergencies effectively. Included are such items as multiple manning at the critical locations; multiple location activation steps for major procedures; redundant communications, including multiple telephone outlets and radio systems; shock limiting or absorbing devices on piping where rapid closure of automatic valves could cause fluid hammer; relief valves between cryogenic block valves to avoid overpressure; automatic stoppage of pumps and other moving equipment in case of pressure drop; and multilocation push-button stoppage in case of external emergency and as a redundant backup for the automatic system.

As a result of these precautions, should a leak occur, the probability is that the effect would be limited to small quantities of LNG or vapors. Any such leaks should be isolated by valve closures followed by purging and repair. Water spray will be provided to direct LNG vapors away from sources of ignition, and to protect personnel and equipment from flame radiation. High-expansion foam will suppress cold vapor release. Any fires caused from these leaks will be extinguished using standard, dry chemical extinguishers.

Potential contact with major fire (that is, from external structures) or its radiation is minimal. Nevertheless, fire protection facilities will be adequate to protect the facilities from a major fire. Other fire protection provisions include design and selection of materials to prevent collapse or bursting of LNG-containing structures, piping, and equipment exposed to fire.

8.2.7 Summary

Introduction

Section 8.2 of this volume discusses a pipeline-LNG alternative and other pipeline-LNG variations to the all pipeline Arctic Gas System Route. The concept of transporting Alaska natural gas by a chilled 42" gas pipeline from Prudhoe Bay to a port on the southern or western coast of Alaska, liquifying the gas, transporting the LNG (liquified natural gas) by tankers to a harbor on the coast of California, regasifying the LNG, and routing the gas to the western and eastern United States by new and existing pipelines, is common to the pipeline-LNG alternative route and its variations.

The pipeline-LNG alternative route, Prudhoe Bay - Gravina Point - LNG tanker route - Point Conception - points east, is described and discussed in detail. Environmental descriptions and impact considerations common to all the routes are analyzed more thoroughly in the sections on the pipeline-LNG alternative, especially the marine route and the routing of Alaska gas to the eastern United States.

Three route variations in Alaska, Prudhoe Bay to Cook Inlet, Prudhoe Bay to Haines, and Prudhoe Bay to Golovin, are discussed primarily as they contrast to the prime alternative in alignment and impact on the environment. The salient factors pertaining to the four pipeline routes and their marine routes to California are presented in Table 8.2.7-1.

The Point Conception, California regasification plant and the necessary pipeline systems to transport Alaska gas to existing pipelines are discussed as are the two variations to this system: Oxnard, California regasification plant to Hinkley, and Los Angeles Harbor, California regasification plant to Yorba Station - Jal, New Mexico. Table 8.2.7-2 presents the salient factors pertaining to the three pipeline systems originating at Point Conception, Oxnard, and Los Angeles, California.

Significant impacts on the environment from the alternative routes can be expected to occur during both construction and operation phases of the project. One important major impact caused by construction of the pipeline will be the degradation of the permafrost regime, particularly in the ice-rich permafrost regions of Alaska. Extended winter work schedules when combined with inadequate snow cover will create disturbance of the surface-active layer of the permafrost causing erosion, slumping, mass wasting and gullying during the summer thaw.

The most significant of project impacts from any of the alternative routes or the prime route will be socio-economic. The increases in population created by the large work forces will have both a beneficial and adverse effect on the population centers of Alaska, especially Fairbanks. Increase in trade to local business, tax base, and cultural activities will be beneficial, but added pressures on public schools, utilities, services, recreation, and housing, with attendant increases in water and air pollution, crime, and inflation, will adversely affect the quality of life and degrade the environment.

Other major impacts include depletion of available fresh water during winter and its adverse impact on aquatic life, depletion of gravel sources that are already reduced in areas along the Alyeska oil pipeline, and disturbance and/or long term adverse effects on endangered species and other animal populations by the destruction of winter foods or displacement from nesting areas, spawning streams, dens, or calving grounds.

Table 8.2.7-1 LNG alternative, comparison of trans-Alaska pipeline and marine routes from Prudhoe Bay, Alaska to California via selected Alaskan ports.

	Gravina Point	Cook Inlet	Haines	Golovin
Length of Route	2995	3208	3015	4200
Miles of Pipeline	810	850	1060	750
Shipping Lane (nautical miles)	1900	2050	1700	3000
Tanker Traffic Problems	Moderate to high (Both oil & gas super tankers)	Moderate	Moderate	None
Ice Problems	Moderate (Columbia Glacier icebergs)	Moderate (Broken ice north of the Forelands)	None	Severe (up to 736 miles of ice 9 months of the year)
Number of Ships	12	13	11	18
Total miles of Permafrost	780	640	860	750
Miles of Ice-Rich Permafrost	380	300	450	380
Miles Along Existing Roads or Pipelines	765	850	1060	60
Number of Major Rivers Crossed	23	29	21	12
Miles Through Undeveloped Areas	46	none	none	690
Miles Through Cultivated Areas	10	20	60	none
Number of Major Mountain Pass Crossings	2	2	2	1
Earthquake Potential (magnitude)	High (South end 8.4)	High (South end 8.4)	High (South end 7.0)	Slight
Native Villages 1/				
Number	5	4	8	9
Population	567	275	653	914
Sensitive Wildlife Areas				
Caribou Calving Grounds	None	None	None	None
Caribou Migration Routes	110	105	90	140
Waterfowl Habitat	120	170	155	120

1/ Only villages within 50 miles of the corridor and with 50% or greater native population were included.

Table 8.2.7-2 Combination pipeline - LNG tankers system comparison of delivery routes from California receiving terminals to marketing areas 1/.

	Terminal: Pt. Conception, CA (Route via Arvin, CA)	Terminal: Oxnard, CA (Route via Hinkley, CA)	Terminal: Los Angeles, CA (Route via Yorba, CA)
Length of Route (miles) 2/	3709	3615	3214
Miles Served by Existing Pipelines	2905	2905	2625
New Pipelines	937 (Incl. 384 mi. 3/ in CA and 553 mi. in TX)	722 (Incl. 169 mi. 4/ in CA and 553 mi. in TX)	589 (Incl. 36 mi. in in CA and 553 mi. in TX)
Miles Along Existing Roads or Pipelines	378	221	391
Number of Major Rivers Crossed	11	8	8
Miles Through Undeveloped Areas	91	54	54
Miles Through Cultivated Areas	174	159	100
Number of Major Mountain Pass Crossings	8	3	0
Earthquake Potential (Magnitude)	High (So. CA 6.0-8.2)	Moderate (Oxnard thru San Andreas fault, 5.5)	High (Fault at Los Angeles, 8.2)
Native Villages 5/			
Number	none	none	none
Population	0	0	0
Sensitive Wildlife Areas			
Caribou Calving Grounds	none	none	none
Caribou Migration Routes	none	none	none
Waterfowl Habitat	none	none	none

1/ Marketing areas are in California, northcentral and northeastern U.S. as specified for the prime proposal.

2/ Length of routes include straight-line distances through existing pipeline systems from southern U.S. to northcentral and northeastern U.S.

3/ Includes two pipelines along the same route for 133 miles.

4/ Includes two pipelines along the same route for 12 miles.

5/ This would apply only in Alaska.

Two significant impacts on the environment unique to the alternative route and the variations will be the frost bulb created by the chilled gas pipeline and the return of large volumes of water to the sea at the LNG plant during the liquification process. The frost bulb will provide an impermeable barrier to the natural movement of water for several feet below the pipe, causing concentrations of flow of water, damming, localized erosion, or gullying. Water returned to the sea from the LNG plant will be 21°F above ambient seawater temperature. This would cause adverse impacts on aquatic life. The creation of an unstable warm water environment that could be destroyed by a shut down of the LNG plant would cause severe stress and shock in aquatic life that would become accustomed to the warmer water. The warm water could also alter, delay, or block migrations of both adult and juvenile salmon.

Another feature unique to the alternative route and the variations is the transportation of LNG by a fleet of super tankers with capacities of 165,000 cu. meters of liquefied natural gas. Under normal conditions the operation of the ships would have little impact on the environment except for occasional spills of fuel and lubricating oils or LNG during loading or unloading. However, the hazards associated with the handling and transporting of the highly flammable and unstable material will provide a constant threat. Collision or other mishaps could create sudden and disastrous impacts, especially near land.

The hazard of earthquakes is a potential threat to all the proposed projects in Alaska, but the greatest impact would occur at the LNG plant sites on the Southern Alaska Coast. Central and Southern Alaska have experienced more frequent and severe earthquakes than Northern Alaska, so the pipeline systems could also be subjected to damage from earthquakes.

The significant impact on the environment from the construction of a regasification plant on the California coast will be the return of large volumes of seawater at 12°F below ambient seawater temperatures and the adverse effect on warm water aquatic and other marine life. There will be some impact on the topography as a result of ridge cutting for a pipeline in the Tehachapi Mountains in California.

The regasification plantsites in California and most of the new pipeline systems from the plants also lie in areas of high seismicity. One major hazard to be considered is the construction and operation of a regasification plant and LNG storage tanks in a heavily populated area with a history of earthquakes, such as Los Angeles.

Possible adverse impacts from the construction and operation of the alternative and for the variations on endangered species could occur because of the proximity of the regasification plant to the nesting colony of the brown pelican at Anacapa Island, the proximity of the Waha - Refugio pipeline to the nesting areas of the American Peregrine Falcon in western Texas and the proximity of the same pipeline to the rapidly decreasing habitat of the Attwaters Prairie Chicken in the vicinity of Refugio, Texas.

The alternative and variations do not clearly describe the routing of Alaskan gas through existing pipelines to the Eastern United States. Displacement of gas supplies traditionally transported from the Texas panhandle and Gulf Coast entails exhange agreements between gas pipeline companies and the companies that will deliver Alaskan gas. Modifications to the pipelines to provide reverse flow would be required and possibly new pipelines would have to be constructed to provide looping. The information necessary to design the most efficient system that would utilize existing pipelines is not available at this time.

The combination pipeline-LNG tanker alternative is representative of a concept different from that proposed by the applicant. The salient factors pertaining to the entire gas transportation system of this alternative system and its variations from Prudhoe Bay, Alaska via pipeline to an Alaskan port, via LNG tanker from Alaska to a California port, and then via pipeline to markets in California, northcentral and northeastern United States are presented in Table 8.2.7-3. The data in this table are organized so that comparisons can be made with the salient factors of the applicants proposal as presented in Table 8.OV.3-1 in the Overview volume.

Summary of Major Impacts

Pipeline-LNG Alternative Route: Prudhoe Bay - Gravina Point - Point Conception - Points East

The Pipeline from Prudhoe Bay to Gravina Point and the Gravina Point Terminal

1) Inadequate snow, particularly in the North Slope areas, would alter construction procedures and may extend the construction season resulting in additional degradation of the permafrost regime due to additional construction activity during the summer thaw season. Soil erosion, slumping solifluction, mass wasting, and gullying would all be accentuated by the additional disturbance of the active layer.

2) Use of the limited supply of fresh water available during the winter to supply camps, to ice winter roads, to manufacture snow, or for other purposes would cause an adverse impact on aquatic life.

3) Degradation of the permafrost regime is the most important environmental factor related to the construction, operation, and maintenance of the pipeline system. Impacts will be particularly severe in ice-rich permafrost zones - soil subsidence, soil erosion, and gullying could continue for years. Long-term influence on soil, water, vegetation, and wildlife can result. Industry has not demonstrated that a buried, chilled pipeline can be operated safely in the permafrost region, especially in the discontinuous permafrost zone.

Severe cold combined with darkness and blowing snow would delay or even halt construction beyond the planned two-winter construction schedule causing major adverse impacts on the permafrost regime with associated severe impacts on vegetation water quality, and soil stability as well as causing a delay in the delivery of the natural gas to market.

4) Depletions of gravel sources already reduced by the Alyeska project will be severe but localized if gas pipeline requirements are held to the estimated 6.7 million cubic yards. However, gravel requirements could reach 30 million cubic yards or more if the proposed, highly idealized, and presumptive work schedules are not met. Impacts on gravel resources and associated aquatic and riparian stream habitat would be severe throughout the entire pipeline route.

5) There is high seismic risk at two areas. One area is the Delta river region of the Alaska Range where a severe earthquake occurring along the Denali fault could cause structural damage or rupturing of the pipeline. The Chugach Range and Prince William Sound is the second area. An event at the LNG Gravina site, plant and docking facilities, could severely damage or destroy the plant, the docks, and any tankers in the vicinity should an explosion be triggered by the shaking effect of the earthquake.

6) Impacts with possible long-term adverse effects on animal populations include the loss of wolf den sites, disturbance of Dall Sheep on their winter and spring calving grounds adjacent to the pipeline in the Brooks Range, destruction of winter foods and displacement from sheltered areas of the small moose herd on the North Slope, and the interruption of nesting of peregrine falcons (an endangered species) adjacent to the route.

Wildlife would also be impacted by increased access for illegal hunters and recreationists causing displacement and reduction in animal populations. Potentially severe impacts could result from aircraft harassment of animals especially during the mating season and during the winter when they could be placed in a negative energy balance situation leading to mortality. The Dall Sheep would be especially vulnerable to aircraft harassment as would the wolf.

7) The impact of the proposed project is adverse and major on the wilderness character of the Prince William Sound Unit of the Chugach Mountains National Forest and the Gravina Point area. This impact encompasses 46 miles of the pipeline system.

8) The hugh volume (658,000 gallons per minute) of water returned by the Gravina LNG plant's once-through cooling system to Orca Bay at 21 °F above ambient seawater temperature would cause adverse impacts on aquatic life. One, it could alter, delay, or block the migrations of both adult and juvenile salmon; and two, a shut-down of the once-through system would cause severe stress and shock in aquatic animals which had become accustomed to the warmer water.

9) The socio-economic impact of the gas pipeline would be the most significant of all project impacts and would be both beneficial and adverse. The primary population center affected would be the Fairbanks area. The beneficial impacts include an increase in trade to local business, an increased tax base for cities, and increase in cultural activities. The adverse impacts include increased social problems (crime, crowding of schools, etc.), accelerated inflation, lower standards and shortage of housing, and an acceleration in the decline of Native culture.

10) The frost bulb formed around the refrigerated pipeline will impound and divert ground and surface waters creating erosion locally and a potential for interfering with migration by anadromous fish.

LNG Transport (Marine Route)

11) An accident involving a single LNG tanker or a collision with another ship would result in the production of a hugh super-cooled cloud of gas, a fire, an explosion singly or in combination, or all three in sequence. The possibility of such an event occurring cannot be discounted.

12) An LNG tanker accident could have severe adverse effects with a loss of human life and destruction of nearby boats and ships and shore facilities. An accident at or near the LNG plant could wipe out tankers and docking facilities as well as the plant with a catastrophic loss of human lives and property.

13) The impact on bald eagles and sea otters could be severe. An accident in Prince William Sound, in addition to the tragic loss of human life, could kill waterfowl and sea otters; similarly, an accident near or at Hinchinbrook Entrance could cause a significant loss of seabirds. An accident anywhere in the Prince William Sound region could result in the

destruction of fishing boats, fishing gear, recreational boats and a loss of human life in addition to the loss of the tanker and its crew.

14) An accident on the open sea would have a minor effect on fish, wildlife and other aquatic organisms other than some local mortality but could result in the loss of the tanker and its crew.

15) An accident at or near the regasification plant at Point Conception could result in a loss of human life and property similar to the catastrophic losses at the Gravina LNG site.

16) The most severe impact to fish and wildlife would result from a collision between an LNG tanker and an oil tanker and the resulting oil spill. Depending on the time of year and locale of the event high mortality of sea birds and waterfowl could result in certain situations, larval forms of shellfish and young finfish could suffer heavy losses from oil spills; additionally nets and other fishing gear could be so contaminated as to be useless for future fishing activity.

The Point Conception Terminal and the Pipeline from Point Conception to Eastern United States

17) The proposed addition of 300,000 gpm of seawater 12° F below ambient seawater temperature from the revaporization plant into the Pacific Ocean near Point Conception could have an adverse impact upon some of the 721 species of aquatic organisms found in the area. Some warm water species could be forced from the area while cold water species could be adversely affected should the cold water be discontinued without time for their acclimation to the warmer water.

18) The impact on topography would be severe from the Point Conception regasification site along the gas pipeline route to Arvin. Two million cubic yards of earth will be moved and two acres filled at the plant site. Approximately 50 percent (71 miles) of 142.3 mile Point Conception to Arvin route may require ridge cuts (leveling of ridge crests).

19) The socio-economic impact of the Point Conception to Arvin pipeline could be significant on Santa Barbara County and would be both beneficial and adverse during the projected 39-month construction period. The beneficial impacts include an increase in local business; an increased tax base; and an increase in economic well-being for residents of the county. The adverse impacts include additional educational facilities required, shortage of housing, and an increased demand for municipal services.

20) Construction of the Point Conception regasification plant would involve the installation of a major industrial facility in a rural, agricultural area. It would also present a direct conflict to development of the 135-parcel, 100-acre minimum development on the adjacent Hollister Ranch. The development of offshore tanker docking facilities would conflict directly with commercial and recreational use of the offshore area.

21) No major impacts are identified in connection with the pipeline from Arvin to points east.

Variation: Prudhoe Bay to Cook Inlet - Alaska

Alaska Pipeline and LNG Plant Site

1) Same as Pipeline - LNG Alternative Route Impact 1, above

2) Same as Pipeline - LNG Alternative Route Impact 2, above

3) Same as Pipeline - LNG Alternative Route Impact 3, above

4) Same as Pipeline - LNG Alternative Route Impact 4, above

5) The seismicity is very high in the southern section of the route with a potential of earthquakes of magnitude 8.5.

6) Same as Pipeline - LNG Alternative Route Impact 6, above

7) Pipeline - LNG Alternative Route Impact 7 not applicable

8) Same as Pipeline - LNG Alternative Route Impact 8, above

9) The socio-economic impact on Fairbanks and Anchorage would be both beneficial and adverse. The beneficial impacts include - an increase in trade to local business; an increased tax base for cities; and an increase in crime; crowding of schools; inflation; a lower standard and shortage of housing; and an acceleration in the decline of Native culture.

10) The high susceptibility to fire and difficulty to control in the lowland spruce/hardwood vegetation of the Kenai Peninsula gives this area a high potential for damage to property and human life.

11) The archeological sites of Nenana Canyon, Ester and Fox Tailings, and Esther Dome could be destroyed or damaged. The impact on undiscovered sites would be adverse or favorable in that they could be destroyed or discovered.

12) The pipeline route would have a major impact on Mt. McKinley National Park where the route passes close to and crosses inside its east border.

13) The major impact to land use would be favorable as the route follows existing transportation corridors the whole way.

LNG Transport (Marine Route) Cook Inlet

1) Same as Pipeline - LNG Alternative Route Impact 11, above

2) Same as Pipeline - LNG Alternative Route Impact 12, above

3) Pipeline - LNG Alternative Route Impact 13 not applicable

4) Same as Pipeline - LNG Alternative Route Impact 14, above

5) Same as Pipeline - LNG Alternative Route Impact 15, above

6) Same as Pipeline - LNG Alternative Route Impact 16, above

7) The presence of ice in Cook Inlet could at times interfere with the LNG tanker traffic.

Variation: Prudhoe Bay to Haines - Alaska

Alaska Pipeline and LNG Site

1) Same as Pipeline - LNG Alternative Route Impact 1, above

2) Same as Pipeline - LNG Alternative Route Impact 2, above

3) Same as Pipeline - LNG Alternative Route Impact 3, above

4) Same as Pipeline - LNG Alternative Route Impact 4, above

5) High seismic risk in the Haines area. Earthquakes could cause translatory or rotational slides in the marine clays near Haines and also the risk of tsunamis are significant in this area. High seismic and mass movement risk exist at the southeast end of Kluane Lake at the Slims River crossing where the pipeline enters the Shakwak fault zone.

6) Same as Pipeline - LNG Alternative Route Impact 6, above

7) Pipeline - LNG Alternative Route Impact 7 not applicable

8) Same as Pipeline - LNG Alternative Route Impact 8, above

9) The socio-economic impacts to the major population centers of Fairbanks, and on a lesser scale Haines, are both beneficial and adverse. The beneficial impacts would be: an increase in trade to local businesses; an increased tax base for cities and an increase in cultural activities. The adverse impacts would include: inflation; crowding of schools; a shortage and lower standard of housing; an increase in crime; and an acceleration in the decline of Native culture.

10) There would be a favorable impact to land use as the route follows existing transportation corridors the whole way.

11) The route traverses areas rich in archaeology and history. Pipeline construction activities would have a major adverse impact on two of the most significant archaeological sites in Alaska, the Dixthada and Healey Lake sites.

12) The pipeline would impact the Kluane National Park in the Yukon Territory as it passes close to and at times transects its eastern boundary. The route would also have an impact on the territorial game Sanctuary in Yukon Territory, as it parallels its eastern boundary.

LNG Transport (Marine Route) Lynn Canal

1) Same as Pipeline - LNG Alternative Route Impact 11, above

2) Same as Pipeline - LNG Alternative Route Impact 12, above

3) Pipeline - LNG Alternative Route Impact 13 not applicable

4) Same as Pipeline - LNG Alternative Route Impact 14, above

5) Same as Pipeline - LNG Alternative Route Impact 15, above

6) Same as Pipeline - LNG Alternative Route Impact 16, above

Variation: Prudhoe Bay to Golovin - Alaska

Alaska Pipeline and LNG Site

1) Same as Pipeline - LNG Alternative Route Impact 1, above

2) Same as Pipeline - LNG Alternative Route Impact 2, above

3) Same as Pipeline - LNG Alternative Route Impact 3, above

4) Gravel requirements could reach 30 million cubic yards or more if the proposed, highly idealized, and presumptive work schedules are not met. Impacts on gravel resources and associated aquatic and riparian habitats would be severe throughout the entire pipeline route.

5) Pipeline - LNG Alternative Route Impact 5 not applicable

6) Same as Pipeline - LNG Alternative Route Impact 6, above

7) This route would pass near the proposed Kobuk Valley National Monument, Cape Krusenstern National Monument, Chukchi-Imuruk National Reserve and the proposed Selawick National Wildlife Range may be transected. The route also would greatly impact the proposed Gates of the Arctic National Park.

8) Same as Pipeline - LNG Alternative Route Impact 8, above

9) Socio-economic impacts will be beneficial in that local native corporation revenues would be increased and social and government services would be increased. Adverse impact would be the demand for housing and the decline in Native culture.

10) The route passes through an area with known significant archeological sites along the Kobuk River. There is potential for damage to these sites but also potential for discovery of new sites.

11) Even low emission levels of sulfur dioxide could have a pronounced effect on lichens, although this should have no major impact on caribou.

12) Emergency repair operations in summer would have major permanent adverse impacts to the vegetation of the tundra caused by vehicle traffic.

13) Construction and maintenance of the pipeline could affect the thermal regime of the tundra and by so doing severely damage the drainage of the tundra and impair further repair activities.

LNG Transport (Marine Route) Norton Sound

1) Same as Pipeline - LNG Alternative Route Impact 11, above

2) Same as Pipeline - LNG Alternative Route Impact 12, above

3) Pipeline - LNG Alternative Route Impact 13 not applicable

4) Same as Pipeline - LNG Alternative Route Impact 14, above

5) Same as Pipeline - LNG Altenative Route Impact 15, above

6) Same as Pipeline - LNG Alternative Route Impact 16, above

7) Ice is prevalent in Norton Sound from October to July during which shipping will face hazards of both collision with icebergs and delay of delivery.

Variation: Oxnard to Quigley Station - Hinkley, California - Eastern United States

1) The proposed project would receive up to 475,000 gpm of heated water, via pipeline, from the discharge system of the Ormond Beach Generating Station. The temperature of the heated water would be depressed by about 15°F and returned to the existing outfall line. Since this water has already been treated, additional chemicals would not be needed. The net result would be fewer chemicals added and heating induced by another facility reduced by the proposed facility. These functions would benefit the marine environment.

2) The higher elevation (foothills and steeper mountainous areas) will require modifications to the topography as a result of pipeline construction. These modifications are not extensive and should not have a major long-term effect upon the environment.

3) The payroll for the 39 months of construction of the proposed project would total some $35 million. Ninety percent of this amount would go to the Ventura county area and be injected primarily into the local economy. During June of 1974, some 5,300 persons were engaged in contract construction in Ventura county. The proposed project would employ some 1,900 persons during peak operations. It is estimated that 90 percent of the employees would come from Ventura county. As a result the local economy would benefit and would not be burdened with providing additional services.

4) Pipeline - LNG Alternative Route Impact 20 not applicable

5) Pipeline - LNG Alternative Route Impact 21 not applicable

6) Two endangered species of wildlife could be adversely affected by the proposed project. The Brown pelican nests on Anacapa Island which is directly offshore from the proposed LNG terminal. In addition the California Condor occurs in the Sespi Condor Sanctuary. The proposed pipeline would pass within four miles of the Sanctuary. Increased activity could further harass these two endangered species.

7) The proposed vaporization plant would emit some nitrogen dioxide and sulfur dioxide. The air quality in the Ventura-Oxnard area is already somewhat degraded, but meets state and Federal standards for NO_2 emissions. Emission in the immediate vicinity of the plant could exceed State-Federal standards for NO_2 emissions about once each year.

Variation: Los Angeles to Yorba Station - Blythe - Eastern United States

1) Same as Pipeline - LNG Alterntive Route Impact 17, above

2) Pipeline - LNG Alternative Route Impact 18 not applicable

3) Pipeline - LNG Alternative Route Impact 19 not applicable

4) Pipeline - LNG Alternative Route Impact 20 not applicable

5) Pipeline - LNG Alternative Route Impact 21 not applicable

6) The major impact that climate would have on this route would be caused by the fog and smog conditions of the Los Angeles area. Prolonged periods of fog, or even short periods, would restrict visibility in the harbor posing a safety hazard and a delay in shipping. In the case of a gas spill the vapor cloud of gas would pose a fire danger if held in the Los Angeles area due to an inversion condition.

7) The high potential for earthquakes with a magnitude of 6 to 8 is a major impact on the integrity of the pipeline. The area of this route has many fault systems that add to this risk. The Palos Verdes fault is to the west of the pipeline, the route would cross the Newport-Inglewood fault zone and the Whittier, Chino and San Andreas faults are to the east of Yorba Station.

8) The potential for loss of life and property due to an accident involving a LNG tanker, the LNG terminal or the pipeline is high because of the larger population of the Los Angeles area.

9) The potential for a collision between a LNG tanker and another vessel in the Los Angeles harbor area is high due to the heavy traffic at present and if oil tankers will be using the harbor in the future the risk would be even higher.

Bibliography

Abbott, W. 1973, Curator of Ornithology, Santa Barbara Museum of Natural History, letter dated October 1973 cited in Dames and Moore, 1974, Detailed Environmental Analysis... for Western LNG Terminal Company.

Alaskan Arctic Gas Pipeline Company. 1974. Environmental report, Application of Alaska Arctic Gas Pipeline Company at docket No. CP74-239 for a certificate of public convenience and necessity.

Alaska Commercial Fisheries Entry Commission. 1973. Cook Inlet briefing material. ACFEC Res. Div.

Alaska Department of Economic Development. 1972. Alaska statistical review. State of Alaska. Juneau, Alaska.

----------1973a. The Alaskan economy. (A performance report of the State of Alaska, Dept. of Econ. Dev.) Juneau, Alaska 31 p.

-----------1973b. A profile of Alaskan communities. State of Alaska. Juneau.

Alaska Department of Fish and Game. 1968. Federal Aide in Wildlife restoration. Segmental report 9.

----------1973, Alaska's wildlife and habitat. State of Alaska, Juneau.

Alaska Game Commission. 19752. Report to the Secretary of Interior. Alaska Game Commission Report 13.

Ashmole, N. P. 1971. Seabird ecology and the marine environment. Pages 223-286 in D.S. Farner and J.R. King, eds. Avian biology, Volume l. Academic Press, New York. New York.

Barnery, R.J. 1971a. Wildfires in Alaska - some historical and projected effects and aspects. Pages 51-59 in C.W. Slaughter, R.J. Barnery, and G.M. Hansen, Fire in the northern environment--a symposium. Pacific Northwest For. and Range Exp. Stn. U.S. Dept. Agric., Portland, Oregon.

-----1971b. Selected 1966-69 interior Alaska wildfire statistics with long-term comparisons. Pacific Northwest For. and Range Exp. Stn., U.S. Dept. Agric. For. Serv. Res. Note PNW-154. Portland, Oregon.

Bantonek, J.C. 1969a. Arctic Slope and trans-Alaska pipeline task force report. The bird resources of Alaska's Arctic Slope and petroleum development. Bureau of Sport Fisheries and Wildlife, Administrative Report, Northern Prairie Wildlife Research Center.

Bantonek, 1969b. Arctic Slope and trans-Alaska pipeline report. Bird resources along the trans-Alaska pipeline. Bureau of Sport Fisheries and Wildlife, Administrative Report. Northern Prairie Wildlife Research Center.

Barsdate, R.J., M. Nebert, and C.P. McRoy. 1974. Lagoon contributions to sediments and water of the Bering Sea. Pages 553-576 in D.W. Hood and E.J. Kelley, eds. Oceanography of the Bering Sea. Institute of Marine Science, Occasional Publication No. 2, University of Alaska, Fairbanks.

Beatley, J.C., 1967, "Survival of Winter Annuals in the Northern Mojave Desert", Ecology, Vol. 48, pp. 745-750.

Beatley, J.C., 1969, "Dependence of Desert Rodents on Winter Annuals and Precipitation", Ecology, Vol. 50, pp. 721-724.

Bee, J.W. and E.R. Hall. 1956. Mammals of northern Alaska and on the Arctic Slope. Univ. of Kansas Mus. of Nat. Hist. Misc. Pub. No. 8. Lawrence, Kansas.

Berkwith, R.C. 1972a. Scotylid flight in white spruce stands in Alaska. Canadian Entomology 104: 1977-1983.

-----1972b. Key to adult bark beetles commonly associated with white spruce stands in interior Alaska. U.S. Forest Service Research Not PNW-189.

Bender, K., 1973, California Least Tern Census and Nesting Survey, Special Wildlife Investigations, Progress Report, Job II-11, California Department of Fish and Game, Sacramento.

Berkman, S.C., and J.M. Symons, 1974, The Tsunami of May 22, 1960 as Recorded at Tide Stations, U.S. Department of Commerce, Coast and Geodetic Survey, Washington, D.C.

Berton, P. 1972. Klondike. McLelland and Stewart Limited, Toronto. 472 p.

Bishop, R. 1969. Moose report. Alaska Department of Fish and Game. Federal Aid in Wildlife Research Report 10.

Biswell, H.H., 1956, "Ecology of California Grasslands", Journal of Range Management, Volume 9, pp. 19-24.

Bloch, S. 1964. Wildlife losses in oil sumps in the San Joaquin Valley. California Dept. Fish and Game, Region 4. Fresno. unpubl. admin. rept.

Boucher, G. and T.J. Fitch. 1969. Microearthquake seismicity of the Denali Fault. Journal of Geophysical Research 74(27): 6638-6648.

Brame, A.H., Jr., and K.F. Murray, 1968, "Three New Slender Salamanders (Batrachoseps) with a Discussion of Relations and Speciation within the Genus, Bulletin of the Los Angeles County Museum of Natural History, Science, No. 4.

Bramhall, E.H. 1938. The Central Alaska earthquake of July 22, 1937: Seismol. Soc. America Bull., v. 28, p. 71-75.

Buck, E.H. 1973. National patterns and trends of fishery development in the North Pacfic. Arctic Environmental Date Center, University of Alaska, Anchorage.

Buckley, J.L. and W.L. Libby. 1957. Research reports on aerial interpretation of terrestrial bioenvironmentals and faunal populations. Arctic Aeromedical Laboratory. U.S. Air Force Technical Report 57-32.

Burgess D. and M.G. Zabetokis. 1962. Fire and explosion hazards associated with liquefied natural gas. USDI, Bureau of Mines, Report of Investigations 6099. 34 pages.

Bury, R.B., 1972, Status Report on California's Threatened Amphibians and Reptiles, Inland Fisheries Administrative Report No. 72-2, California Department of Fish and Game, Sacramento.

Cahalane, Victor, 1961, Mammals of North America, The Macmillan Company, New York.

Caldwell, D.K., M.C. Caldwell, and D.W. Rice. 1966. Behavior of the sperm whale, Pyster catodon L. Pages 677-717 in K.S. Norris ed., Whales, dolphins, and porpoises. University of California, Berkeley.

California Department of Fish and Game, 1974, At the Crossroads, A Report on California's Endangered and Rare Fish and Wildlife, California Department of Fish and Game, Sacramento.

Cannon, R. 1970. How to fish the Pacific coast. Lane Brooks, Menlo Park, California.

Castenholz, R.W. 1961. The effect of grazing on marine littoral diotom populations. Ecology 42: 783-794.

Chaphman, J.A., C.J. Henney, and H.M. Wight. 1969. The status, population dynamics and harvest of the dusky Canada goose. Wildlife Monograph No. 18.

Chapman, V.J. 1960. Salt marshes and salt deserts of the world. Interscience Publishers.

Cody, M.L., 1971, "Finch Flocks in the Mojave Desert", Theoretical Population Biology, Vol.2, pp. 142-158

Cogswell, Howard 1974, "Chaparral Country", Audubon Magazine, Vol. 49, pp. 75-81.

Cole, R., et. al., 1958, Soil Survey of the Bakersvield Area, California. U.S. Department of Agriculture.

Collins, G. 1937. A report of the Arctic patrol made during the winter of 1936-37. Alaska Game Commission. Unpublished.

Cordone, A.J. and D.W. Kelley. 1961. The influence of inorganic sediment on the aquatic life in streams. Calif. Fish and Game 47: 189-228.

Coulter, H.W. and E.B. Coulter. 1961. Geology of the Valdez (A-S) quadrangle, Alaska. U.S. Geological Survey, Geological Quadrangle Map GQ-142.

Curtin, G. 1973. Collapsing soil and subsidence. Pages 89-100 in D.E. Moran, J.E. Slossom, R.O. Stone and C.A. Yelverton eds. Geology, seismicity and environmental impact. Association of Engineering Geologists Special publication.

Dames & Moore, 1975, Detailed Environmental Analysis Concerning Proposed Liquefied Natural Gas Facilities And Associated Gas Transmission Pipelines For Western LNG Terminal Company, Volumes I - VI.

Dames & Moore, 1975, Detailed Environmental Analysis Concerning Proposed Liquefied Natural Gas Facilities And Associated Gas Transmission Pipelines For Western LNG Terminal Company, Gas Transmission Pipeline From Arvin to Cajon, California, FPC Docket No. CP75-83.

Darnell, R.M. 1967a. Organis detritus in relation to the ecosystem. Pages 377-382 in G.H. Lauff, ed. Estuaries. Publication 83, American Assoication for the Advancement of Science, Washington.

-----1967b. The organic detritus problem. Pages 374-374 in G.H. Lauff, ed Estuaries. Publication 83, American Association for the Advancement of Science, Washington.

DeLeonardis, S. 1971. Effects of fire and fire control methods in interior Alaska. Pages 101-105 in C.W. Slaughter, R.J. Barney, and G.M. Hansen, eds. Fire in the northern environment--a symposium. Pacific Northwest For. and Range Exp. Stn., Dept. Agric., Portland, Oregon. 275 p.

Department of the Army Corps. of Engineers, Alaska District. 1974. Offshore oil and gas development in Cook Inlet, Alaska. Final Environmental Impact Statement. 446 p.

Department of Economic Development. 1973. A performace report of the Alaska economy. State of Alaska.

Dickey, T.R. et al. "U.S. Coast Guard Registration and ICMO Recommendations for LNG Tankers," U.S. Coast Guard, January 1974.

Dodimead, A.J., F. Favorite and T. Hirano. 1963. Review of the oceanography of the Subarctic Pacific region. International North Pacific Fisheries Commission, Bulletin 13, Vancouver, British Columbia.

Doran, L.D. 1974. Fishes and aquatic systems. Pages 205-268 in Research Reports Vol. IV of Environmental impact assessment of the portion of the Mackenzie gas pipeline from Alaska to Alberta. Environmental Protection Board, Winnipeg, Manitoba.

Druehl, L.D. 1970. The pattern of Laminariales distribution in the Northeast Pacific. Phycologia 9 (3/4): 237-246.

Ellis, M.M. 1936. Erosion silt as a factor in aquatic environments. Ecology. 17: 29-42.

El Paso Alaska Company. 1974. Environmental report, Volume III, Application of El Paso Alaska Company at docket No. CP75-96 for a certificate of public convenience and necessity.

Environment Protection Board. 1974. Environment impact assessment. Environment Protection Board (Corridor). Four vols.

Evans, C., E. Buck, R. Buffler, G. Fish, R. Forbes and W. Parker. 1972. Cook Inlet Environment - Background study of available knowledge. Report for Alaska District, Corps of Engineers, Anchorage, Alaska.

Fay , J.A. and J.J. MacKenzie. 1972. Cold Cargo. Environment 14 (9): 21-29.

Federal Power Commission. 1974. Final environmental impact statement for the construction and operation of an LNG import terminal at Staten Island, New York. Washington.

Federal Power Commission, 1975a, Bureau of Natural Gas, Draft EIS For The Alaskan Arctic Natural Gas Transportation System, Volumes I-III, Western LNG Terminal Company Docket NO. CP 75-83-1, November.

Federal Power Commission, 1975b, Final Environmental Impact Statement for the Construction and Operation of a Natural Gas Pipeline and Related Compressor Stations in the State of Texas. El Paso Natural Gas Co. Docket No. CP73-260.

Ferrians, O.J., Jr. 1965. Permafrost map of Alaska: U.S. Geol. Survey Misc. Geol. Inv. Map I-445, scale 1:2, 500,000.

-----1966. Effects of the earthquake of March 27, 1964 in the Copper River Basin area, Alaska: U.S. Geol. Survey Prof. Paper 543-E.

-----1971. Preliminary engineering geologic maps of the proposed trans-Alaska pipeline route--Beechey Point and Sagavanirtok quadrangles: U.S. Geol. Survey open-file report.

-----R. Kachadoorian, and G.W. Greene. 1969. Permafrost and related engineering problems in Alaska: U.S. Geol. Survey Prof. Paper 678. 37 p.

Foster, H.L. 1970. Reconnaissance geologic map of the Tanacross quadrangle Alaska: U.S. Geological Survey, Miscellaneous Geological Inventory Map I-593.

Gates, G.O., Grantz, and W.W. Patton, Jr. 1968. Geology and natural gas and oil resources of Alaska. American Association of Petroleum.

Gavin, A. 1970. Ecological survey of Alaska's North Slope, summer 1969 and 1970. Atlantic Richfield Company.

----- 1975. Wildlife of the North Slope/a five-year study, 1969-1973. Atlantic Richfield Co.

Gedney, L. and E. Berg, 1969. The Fairbanks earthquakes of June 21, 1967; aftershock distribution, focal mechanisms, and crustal parameters: Seismological Society of America Bulletin 59 (1): 73-100.

-----E. Berg, H. Pulpan, J. Davies and W. Feetham 1969. A field report on the Rampart, Alaska Earthquake of October 29, 1968: Seismological Society of America Bulletin, 59 (3): 1421-1423.

-----, L. Shpiro, D. Van Wormer and F. Weber. 1972. Correlation of epicenters with mapped faults, east central Alaska, 1968-1971, U.S. Geol. Survey Open-file Rep.

Gilmore, T.M. and T.R. Hanna. 1974. Regional monitoring of ambient air carbon monoxide in Fairbanks, Alaska. Journ. Air Pollution Control Assoc. 24(11): 1077-1079.

Greewood, Ned H., and J.M.B. Edwards, 1973, Human Environments and Natural Systems, A Conflict of Dominion, Duxbury Press, North Scituate, Massachusetts.

Grinnel, J., and A.H. Miller, 1944, "The Distribution of the Birds of California", Pacific Coast Avifauna, No. 27.

Hamilton, T.D. 1973. Late Quaternary glacial history, Delta-Johnson Rivers region, northeastern Alaska Range: Final Report, N.S.F. Grant GS-2584, 43 p.

Hanson, H.C. 1951. Characteristics of some grassland, marsh, and other plant communities in Western Alaska. Ecological Monographs 21(4): 317-375.

-----1962. Canada Geese of coastal Alaska. North American Wildlife and Natural Resources Conference Transactions 17: 301-320.

Hance, J.H., 1937. The recent advance of Black Rapids glacier, Alaska: Journ. Geology, 45 (7): 775-783.

Hand, J.S. 1967. Identification of destructive Alaska forest insects. U.S. Forest Service, Pacific Northwest Forest and Range Department Station.

Hart, J.L. 1973. Pacific fishes of Canada. Fisheries Research Board of Canada, Bulletin 180, Ottawa.

Hatler, D.F. 1967. Some aspects of the ecology of the black bear (Ursus americana) in interior Alaska. Unpublished M.S. thesis. Univ. of Alaska. College, Alaska.

Hemming, J.E. 1971. The distribution and movement patterns of caribou in Alaska. Alaska Dept. of Fish and Game, Wildlife Technical Bulletin No. 1. Juneau.

Hinde, H.P. 1954. The vertical distribution of salt marsh phanerogams in relation to tide levels. Ecological Monographs 24: 209-225.

Howell, B.F. Jr. 1973. Average regional seismic hazard index in the United States. Pages 277-285 in D.E. Moran, S.E. Slosson, R.O. Stome, and C.A. Yelverton, eds. Geology, seismicity, and environmental impact. Association of Engineering Geologists, Special Publication.

Houston, J.R., and A.W. Garcia, 1973, Type 16 Flood Insurance Study: Tsunami Predictions for Pacific Coastal Communities, U.S. Army Engineer Waterways Experiment Station Hydraulic Laboratory, Vicksburg, Mississippi.

Howitt, Frank, and N.W. Clegg. 1970. Permafrost in Prudhoe Bay Field; geology and physical characteristics (abs.): Am. Assoc. Petroleum Geologists Bull. 54 (12): 2487.

Hoyt, D.F., 1972, Mojave Ground Squirrrel Survey, California Department of Fish and Game, Sacramento.

Human Resources Planning Institute. 1974. Manpower and employment impact of the trans-Alaska pipeline. Vol. I. Summary of findings and conclusions. Prepared for U.S. Dept. of Labor, Manpower Admin. Region X. By Human Resources Planning Institute in association with Urban and Rural Systems Assoc. Seattle, Wash.

----------, 1974. A Forecast of industry and occupational employment in the State of Alaska. Institute of Social, Economic and Government Research, University of Alaska.

Humphrey, Robert L. Jr., C. R. Brooks, M. D. Musilo, B. W. Poirier and G. L. Shake, 1975, A Study of Archeological and Historical Potential Along the Trans-Alaskan Natural Gas Pipeline Routes, Vol. 1, Iroquois Research Institute.

Hynes, H.B.N. 1970. The ecology of running waters. Univ. of Toronto Press.

Ingles, Lloyd, 1965, Mammals of the Pacific States, Stanford University Press, Stanford, California.

Institute of Social, Economic and Government Research, University of Alaska. 1971. Alaska Pipeline report.

Johnson, P.R. and C.W. Hartman. 1969. Environmental Atlas of Alaska. University of Alaska. Institute of Arctic Environmental Engineering, Institute of Water Resources.

Johnson, P.L. and T.C. Vogl. 1966. Vegetation of the Yukon Flats region, Alaska. U.S. Army, CRREL, Research Report 209.

Keller, M. and S.W. Harris. 1960. The growth of eelgrass in relation to tidal depth. Journal of Wildlife Management 30: 280-285.

__________Kern County Planning Commission, Open Space and Conservation Element, June 1972.

Kessl, B, R.B. Weeden and G.C. West. 1967. Birdfinding in interior and southcentral Alaska. Alaska Ornithological Society.

King, Calvin L. 1953. Oil sumps-duck nemesis. Wyoming Wildlife. 17(11). pp. 32-33.

King, J.C. 1968a. Average fall duck populations, Alaska -- from principal nesting areas. Bureau of Sport Fisheries and Wildlife. Administrative Report.

----- 1969b. Trumpeter swan survey, Alaska -- 1968. Bureau of Sport Fisheries and Wildlife. Administrative Report.

----- 1970. The swans and geese of Alaska's Arctic Slope. Wildfowl 21: 11-17.

Koontz, K.C. 1968. Small game and furbearers of the Rampart Canyon Dam impoundment area. Master's thesis. University of Alaska.

Kozlik, F.M., 1970, Waterfowl of California, (Revised Edition), California Department of Fish and Game, Sacramento.

Kozloff, E.N. 1973. Seashore life of Puget Sound, the Strait of Georgia and the San Juan Archipelago. University of Washington, Seattle.

Krinsley, D.B., W.E. Davies, J. Rachlin and E.G. Newton. 1971. Existing environment of natural corridors from Prudhoe Bay, Alaska, to Edmonton, Canada: U.S. Geol. Survey Open-file Report 502.

Larrance, J.D. 1971. Primary production in the mid-subarctic Pacific region, 1966-68. National Marine Fisheries Service, Fisheries Bulletin 69(3) 595-613. U.S. Department of Commerce.

Laughrin, Lyndal, 1970, San Joaquin Kit Fox, Its Distribution and Abundance, Wildlife Management Branch Administrative Report No. 70-2, California Department of Fish and Game, Sacramento.

Lent, P.C. 1966. The Caribou of northwestern Alaska. Chapter 19 in N.J. Wilimovsky and J.N. Wolfe, eds. Environment of Cape Thompson region, Alaska. NTIS. Washington, D.C.

Lentfer, J.W., R.J. Hensel, L.H. Miller and V.D. Berns. 1972. Remarks on denning habits of Alaska brown bears. S. Herrero, ed. Bears - their biology and management. IUCN Publ. New Ser. No. 23. pp. 125-132.

Lindholm, G.R. and S.A. Norrel. 1973. Effects of perturbation, nutrient addition, and oil spillage on soil nitrogen cycling at the College hot pipe test site. Pages 72-79 in B.H. McCown and D.R. Simpson (Coords).

The impact of oil resource development on northern plant communities. Institute of Arctic Biology, University of Alaska, Occasional Publication No. 1.

Los Padres National Forest, Personnel communication, June 19, 1975.

Lotspeich, F.B., and E.W. Mueller. 1971. Effects of fire in the taiga on the environment. Pages 45-50. In: C.W. Slaughter, R.J. Barnery and G.M. Hansen, eds. Fire in the Northwest For. and Range Exp. Stn., U.S. Dept. Agric., Portland, Oregon.

Louchs, O.L. 1970. Evolution of diversity, efficiency and community stability. American Zoologist. 10:17-25.

Lutz, H.J. 1956. Ecological effects of forest fires in the interior Alaska. U.S. Dept. Agric. Tech. Bull. 1133.

Lutz, H.J. 1959. Aboriginal man and white man as historical causes of fires in the boreal forest, with particular reference to Alaska. Yale Univ. School of Forestry Bull. 65.

MacFarland, W.N. and J. Prescot. 1951. Standing crop and chlorophyll content and in situ metabolism of a giant kelp community in Southern California. Publications of the Institute of Marine Science 6: 109-220. University of Texas.

Martin, Emmett, and Frederic Clements, 1939, Adaptation and Origin in the Plant World 1. Factors and Functions in Coastal Dunes, Carnegie Institution of Washington, Washington.

Mathematical Sciences Northwest, Inc. 1972. A study of the construction and initial operation of the trans-Alaska pipeline.

Mayhew, Wilbur W., 1968, "Biology of Desert Amphibians", in Desert Biology, Vol. 1 ed. by G.W. Brown, Academic Press New York.

McAllister, C.D. 1969. Aspects of estimating zooplankton production from phytoplankton production. Journal of the Fisheries Research Board of Canada 26: 199-220.

McKay, J.R. 1970. Disturbances to the tundra and forest tundra environment of the western Arctic. Can. Geotech. J. 7:420-432.

McKee, J.E. and H.W. Wolf. 1963. Water quality criteria. State of Calif. State Water Quality Control Board. 2nd. Ed. 548 p.

McPhail, J.D. and C.C. Lindsey, 1970. Freshwater fishes of northwestern Canada and Alaska. Fisheries Research Board of Canada Bulletin 173. 381 p.

McRoy, C.P. 1970. Standing stocks and other features of eelgrass (Zostera marina) populations on the coast of Alaska. Journal of the Fisheries Research Board of Canada 27: 1811-1821.

----- and J.J. Goering. 1974. The influence of ice on the primary productivity of the Bering Sea. Pages 403-421 in D.W. Hood E.J. Kelley, eds. Oceanography of the Bering Sea, Institute of Marine Science, Occasional Paper No. 2, University of Alaska, Fairbanks.

Menzel, D.W. and J.J. Goering. 1966. The distribution of organic detritus in the ocean. Limnology and Oceanography 11:333-337.

Moffit, F.H., 1942. Geology of the Gerstle River district, Alaska, a report on the Black Rapids Glacier: U.S. Geol. Survey Bull. 926-B, p. 107-160.

Montanucci, R., 1965, Observations on the San Joaquin Leopard Lizard, *Crotaphytus wislizenii silus* Stejneger", *Herpetologica*, Vol. 21, pp. 270-283.

Morrel, Stephen, 1972, "Life History of the San Joaquin Kit Fox", *California Fish and Game*, Vol. 58, pp. 162-174.

Motoda, S. and T. Minoda. 1974. Plankton of the Bering Sea. Pages 207-241 *in* D.W. Hood and E.J. Kelley, eds. Oceanography of the Bering Sea, Institute of Marine Science, Occasional Publications No. 2, University of Alaska, Fairbanks.

Munz, P.A., and DD. Keck 1968, *A California Flora*, University of California Press, Los Angeles.

Myron, T. 1971. Evaluatian of the marine fishery resources of Prince William Sound and the Copper and Bering Rivers with respect to the effect of the Valdez oil terminus. Auke Bay Biological Laboratory, mimeo report.

Nathan, Robert (undated), 2(C) Report: Federal Programs and Alaska Natives, Vol. 3, TASKI - An Analysis of Alaska Natives' Well-being.

National Academy of Science. 1972. Conference proceedings on LNG importation and terminal safety, National Academy of Sciences. Boston, Mass. June 1972.

-----1973. Bulk transportation of hazardous materials by water in the future - a long range forecast. National Academy of Sciences, Document Ad-776 618.

National Bank of Alaska. 1974. Alaska's economy in 1974. Midyear review and outlook. NBA. Anchorage, Alaska.

National Ocean Survey, 1974a, *Tide Tables, West Coast of North and South America*.

National Oceanographic and Atmospheric Administration, 1973, *Local Climatogical Data Bakerfield, California*.

Nelso, R.K. 1969. Hunters of the northern ice. University of Chicago, Chicago. 429 pages.

Nicols, F.H. 1975. Dynamics and energetics of three deposit-feeding benthic invertebrate populations in Puget Sound, Washington. Ecological Monographs 45(1): 57-82.

Nishiyama, T. 1974. Energy requirements of Bristol Bay sockeye salmon in the central Bering Sea and Bristol Bay. Pages 321-343 *in* D.W. Hood and E.J. Kelley, eds. Oceanography of the Bering Sea, Institute of Marine Science, Occasional Papers No. 2, University of Alaska, Fairbanks.

Odum, Eugene P., 1971, *Fundamentals of Ecology*, Third Edition, W.B. Saunders Company, Philadelphia.

Ogi, H. and T. Tsujita. 1973. Preliminary examination of stomach contents of murres (*Uria* spp.) from the eastern Bering Sea and Bristol Bay, June-August 1970 and 1971. Japanese Journal of Ecology 23(5): 201-209.

Pacific Southwest Inter-Agency Committee, 1971, Comprehensive Framework Study, California Region, Appendix XIII, Fish and Wildlife, Pacific Southwest Interagency Committee.

Page, R.A. 1971. Microearthquakes of the Denali Fault near the Richardson Highway, Alaska (abs.) American Geophysical Union, Transactions 52: 278.

-----, D.M. Boore, W.B. Joyner, and H.W. Coulter. 1972. Ground motion values for use in the seismic design of the trans-Alaska pipeline system: U.S. Geol. Survey Circular 672, 23p.

Paine, R.T. and R.L. Vodas. 1969. The effects of grazing by sea urchins, *Strongylocentrotus* spp., on benthic algal populations. Limnology and Oceanography 14: 710-719.

Parker,W.B. 1974. International fisheries regimes of the North Pacific. Arctic Environmental Information and Data Center, University of Alaska, Anchorage.

Peattie, Donald Culross, 1953, A Natural History of Western Trees, Bonanza Books, New York.

Peters, J.C. 1965. The effects of stream sedimentation on trout embryo survival. In Biological Problems in Water Pollution. Third Seminar. U.S. Dept. H.E.W. pp. 275-279.

Pewe, T.L. and G.W. Holmes. 1964. Geology of the Mountain Hayes D-4 Quadrangle, Alaska: U.S. Geol. Survey Misc. Geol. Inv. Map I-394.

Pitelka, F.A. 1957. Some aspects of population structure in the short-term cycle of the brown lemming in northern Alaska. Cold Spring Harbor Symposium on Quantitative Biology 22:237-251.

Pirzman, M.S. 1970. Birth behavior and lamb survival in mountain sheep in Alaska. M.S. Thesis. Univ. Alaska.

Plafker, G. 1971. Possible future petroleum resources of Pacific - Marine Tertiary Basin, Alaska. Pages 120-135 in I.H. Cram, ed. Future petroleum provinces of the United States - their geology and potential. American Association of Petroleum Geologists, Memoir 15.

Post, A. S., 1975, Preliminary hydrography and historic changes of Columbia Glacier, Alaska, USGS Open-File Report, 75-491, 11 p.

Price, R. 1972. Effect of human disturbance on Dall Sheep. Quart. Prog. Rep. Alaska Coop. Wild. Res. Unit 23 (3): 23-38.

Reiner, W.A. *et al*. 1971. Plant diversity in a chronosequence at Glacier Bay, Alaska. Ecology 52:55-79.

Richter, D.H., and N.A. Matson Jr., 1971. Quaternary faulting in the eastern Alaska Range. Geological Society of America Bulletin, 82(6): 1529-1539.

Rowe, J.S. 1970. Spruce and fire in northwest Canada and Alaska. Proc. Tall Timbers Fire Ecol. Conf. 10:245-254.

-----, and G.W. Scotter. 1973. Fire in the boreal forest. J. Quat. Res. 3:444-464.

Sage, B. 1971. A contribution to the ornithology of Atigun and Sagavanirktok Valleys. M.S.

Sanger, G.A. 1972a. Fishery potentials and estimated biological productivity of the Subarctic Pacific region. Pages 561-574 in A.Y. Takenouti, et al., eds. Biological oceanography of the North Pacific, Idemitsu Shoten, Tokyo.

----- 1972b. Preliminary standing stock and biomass estimates of sea birds in the Subarctic Pacific region. Pages 589-611 in A.Y. Takenouti, et al., eds. Biological oceanography of the North Pacific. Idemitsu Shoten, Tokyo.

Scarborough, A.M. and P.W. Flanigan. 1973. Observations on the effects of mechanical disturbance and oil cn soil microbial populations. Pages 63-71 in B.H. McCown and D.R. Simpson (Coords.) The impact of oil resource development on northern plant communities. Institute of Arctic Biology, University of Alaska, Occasional Publication No. 1.

Schoephorster, D.B. 1973. Soil survey of Salcha-Big Delta area, Alaska. U.S. Dept. of Agriculture. Soil Conservation Service. 51 pp.

Schofield, E. and W.L. Hamilton. 1970. Probable damage to tundra biota through sulphur dioxide destruction of lichens. Biol. Conservation 2:278-280.

Scholl, D.W., E.C. Buffington, and M.S. Marlow. In manuscript. Plate tectonics and the structural evolution of the Aleutian Bering Sea regions. in R.B. Forbes, ed. The geophysics and geology of the Bering Sea region. Geological Society of America, Memoir 151.

Schweinsburg, R.E. 1974. An ornithological study of proposed gas pipeline routes in Alaska Yukon Territory and the Northwest Territories in 1971. L.G.L. Ltd. Environ. Res. Assoc. for CAGSL/AACSC. Biological Rpt. Series. Vol. 10. 215 p.

Schweinsburg, R. 1974. Disturbance effects of aircraft to waterfowl on North Slope lakes, June, 1972. In W.W.H. Gunn and J.A. Livingston, eds. Studies of disturbance to birds by aircraft and human activity. Calgary, Alberta.

Scott, Michael J. 1975. Analysis of Economic and Social Impact of Alternative Route to the Alaska Arctic Gas Pipeline. Institute of Social, Economic, and Government Research. University of Alaska. Prepared for Bureau of Land Management, USDI. Contract Number YA-512-CT6-68.

Seymore, G., undated, California Condor, the Condor Continues a Dwindling Existence in the Rugged Hills of the Southland, California Department of Fish and Game, Sacramento.

Shaft, M.I., and G.A. Yarranton. 1973. Vegetational heterogeneity during a secondary (postfire) succession. Can. J. Bot. 51:73-90.

Shipman, G.E., C.J. Hilliker, L.C. Leifer, and R.C. Carman, 1972, Soil Survey of the Northern Santa Barbara Area, U.S. Dept. of Agriculture, Soil Conservation Service.

Shuntov, V.P. 1964. Transequitorial migrations of the thinbilled stormy petrel (shorttailed shearwater) - Puffinus tenuirostris (Tenn.) [in Russian] Zoologicheskii Zhurnal 43; 590-598.

Skoog, R.O. 1968. Ecology of the caribou. (Rangifer tarandus granti) in Alaska. Ph.D. Thesis Univ. of Calif. Berkeley. 699 p.

Slaughter, C.W., R.J. Barney, and G.M. Hansen, eds. 1971. Fire in the northern environment - a symposium. Pacific Northwest For. and Range Exp. Stn., U.S. Dept. Agric., Portland, Oregon. 275 p.

Sliepcevich, C.M. 1972. Possible Hazards Associated with Sea Transport of liquefied gases in Bulk. National Academy of Sciences, Committee on Hazardous Materials.

Small, A., 1974, The Birds of California, Winchester Press, New York.

Smith, O.R. 1940. Placer mining silt and its relation to salmon and trout on the Pacific Coast. Trans. Amer. Fish. 69: 225.

Snodgrass, Roland. 1974. Agriculture and range resources, Arctic region. Resource Planning Team. Joint Fed.-State Land Use Plann. Comm.

Soil Conservation Service, 1974. Exploratory soil survey of Alaska. U.S. Dept. of Agriculture. Unpublished report.

Spaeth, M.G., and S.C. Berkman, 1967, The Tsunami of March 28, 1964, as Recorded at Tide Stations, U.S. Department of Commerce, ESSA Technical Report C. & G.S. 33.

State of California Employment Development Department, 1974a.

State of Alaska, 1971. Comments on the proposed trans-Alaska pipeline. State of Alaska report to the U.S. Department of Interior. July 30, 1971.

---- 1974. Criminal justice plan.

Stebbins, Robert, 1954, Amphibians and Reptiles of Western North America, McGraw-Hill Book Company, Inc., New York

Stebbins, Robert, 1966, A Field Guide to Western Amphibians and Reptiles, Houghton Mifflin Company, Boston.

Stephens, F.R. and R.F. Billings. 1967. Plant communities of a tide-influenced meadow on Chichagof Island, Alaska. Northwest Science 41(4): 178-183.

Stout, J.H., J.B. Brody, F. Weber and R.A. Page. 1973. Evidence for Quarternary movement on the McKinley strand of the Denali Fault in the Delta River area, Alaska. Geological Society of America, Bulletin 84. pp. 939-948.

Straty, R.R. 1974. Ecology and behavior of juvenile sockeye salmon (Oncorhynchus nerka) in Bristol Bay and the Eastern Bering Sea. Pages 285-319 in D.W. Hood and E.J. Kelley, eds. Oceanography of the Bering Sea, Institute of Marine Science, Occasional Papers No. 2, University of Alaska, Fairbanks.

Strang, R.M. 1973. Succession in unburned subarctic woodlands. Can. J. For REs. 3: 140-143.

Sweeney, James R., 1956, Responses of Vegetation to Fire, A study of the Herbaceous Vegetation Following Chaparral Fires, University of California Press, Berkley and Los Angeles.

Theberge, J.B., Kluane National Park, The National and Provincial Parks Association of Canada.

Thom H.C.S., 1968, "New Distribution of Extreme Winds in the United States, Journal of the Structural Division, ASCE, Vol. 94 No. 51.

Thomas, H., 1974, Captain, California Department of Fish and Game, San Luis Opispoy, letter dated May 21, 1974, Cited in Dames and Moore, 1974, Detailed Environmental Analysis...for Western LNG Terminal Company.

Thorson, G. 1971. Life in the sea. The World University Library, McGraw Hill, New York.

Tussing, A.R., G.W. Rogers, and V. Fischer, with R.B. Norgaard and G.K. Erickson. 1971. Alaska pipeline report. Institute of Social, Economic and Government Research. Univ. of Alaska, Fairbanks, Ak.

Twisselmann, E.C., 1967, "Flora and Kern County, California," Wasmann Journal of Biology, Vol. 25, pp. 1-395.

U.S. Bureau of Land Management, 1973, Environmental Analysis Record for the Interm Critical Management Program for Recreational Vehicle Use of the California Desert, U.S. Department of the Interior, Washington.

U.S. Bureau of Land Management, 1972, Unit Resource Analysis for the Temblor Caliente Planning Unit, U.S. Department of the Interior, Washington.

U.S. Bureau of Sport Fisheries and Wildlife, undated, Birds of the Kern National Wildlife Refuge, U.S. Department of the Interior, Washington.

U.S. Department of Commerce. 1974. Administration of the marine mammal protection act of 1972. - June 22, 1973, to April 30, 1974. Federal Register 39 (122) 23896-23932.

U.S. Naval Weather Service Command, 1970, Summary of Synoptic Meteorological Observations, North American Coastal Marine Areas, Volume 8.

U.S. Department of the Interior. 1972. Final environmental impact statement proposal trans-Alaska pipeline, Volume 3. Washington.

U.S. Department of the Interior, 1973, Threatened Wildlife of the United States, U.S. Department of the Interior, Washington.

U.S. Department of the Interior, ANGTS. A Report to Congress - A Feasibility Study, 1975.

U.S. Department of the Interior, 1975, Endangered and Threatened Wildlife and Plants. Federal Register, Vol. 40, No. 188; pp. 44412-44429.

---------- 1974. Marine mammals - administrative statue report. 1974. Federal Register 39 (150) 27922-27930.

Vallentine, J.W. 1966. Numerical analysis of marine molluscan ranges on the extratropical northerneastern Pacific shelf. Limnology and Oceanography 11: 198-211.

Van Cleve, K. 1973. Energy and biomass relationship in alder (Alnus) ecosystems developing on the Tanana River floodplain near Fairbanks, Alaska. Journal of Arctic and Alpine Research 5:253-260.

-----, L.A. Viereck, and R.L. Schlentner. 1971. Accumulation of nitrogen in alder (Alnus) ecosystems near Fairbanks, Alaska's Journal of Arctic and Alpine Research 3:101-114.

Van Whye, G.L. 1969. Pipeline impact on sport fish resources. Alaska Department of Fish and Game. Mimeo report.

Vasek, F.C. et al., 1975, "Effects of Pipeline Construction on Creosote Bush Scrub Vegetation of the Mojave Desert," Madrono, Vol. 23, pp. 1-64.

Vierreck, L.A. 1970. Forest succession and soil development adjacent to the Chena River in Interior Alaska. Journal of Arctic and Alpine Research 2: 1-26.

Viereck, L.A. 1973. Wildlife in the taiga of Alaska. J. Quat. Res. 3:465-495.

Van Huene, R.E., E.H. Lathram, and E. Remnity. 1971. Possible petroleum resources offshore in the Pacific margin Tertiary basin, Alaska. Pages 136-151 in I.H. Cram, ed. Future petroleum provinces of the United State - their geology and potential. American Association of Petroleum Geologists, Memoir 15.

Wallace, G., 1974, U.S. Bureau of Land Management, Bakersfield, District Office, Bakersfield, California, personnel communication, May 20, 1974, Cited in Western LNG Terminal Company, 1975, Supplemental Response to FPC Data Request Dated 4-25-75.

Weeden, R.B. and L.N. Ellison. 1968. Upland game birds of forest and tundra. Alaska Department of Fish and Game. Wildlife Bulletin. 3.

Went, F.W., 1948, "Ecology of Desert Plants, I, Observations of Germination in the Joshua Tree National Monument California", Ecology, Vol. 29, pp. 242-253.

Wesson, H.R. et al., 1973. Control of LNG spill fires on land. University Engineers, Inc., Norma. Oklahoma.

Wilbur, S., 1974, Wildlife Biologist, U.S. Fish and Wildlife Service, Ojai, California letters dated May 16, and 20 1974, Cited in Dames and Moore, 1924, Detailed Environmental Analysis...for Western LNG Terminal Company.

Wilimovsky, N.J. 1974. Fishes of the Bering Sea: The state of existing knowledge and requirements for future effective effort. Pages 243-256 in D.W. Hood and E.J. Kelly, eds. Oceanography of the Bering Sea, Institute of Marine Science, Occasional Paper No. 2, University of Alaska, Fairbanks.

Woodward-Envicon, Inc., 1974, Environmental Data Statement, A Natural Gas Pipeline, Nevada-California Border to Cajon, California, Project 73-663, Woodward-Envicon, Inc.

Workmen, K.W. (comp.) 1972. Alaskan archeology: A bibliography. Miscellaneous publications, History and archeology series No. 1. Alaska Division of Parks, Anchorage, Alaska.

Zasada, J.C. 1971. Natural regeneration of interior Alaska forest-seed, seedbed, and vegetative reproduction considerations. Page 231-246 in C.W. Slaughter, R.J. Barney, and G.M. Hansen, eds. Fire in the northern environment - a symposium. Pacific Northwest For. and Range Exp., U.S. Dept. Agric., Portland, Oregon.

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Table 8.2.7-3 Comparison of pipeline-LNG Tanker combination natural gas transportation routes from Prudhoe Bay, Alaska to marketing areas in California, northcentral, and northeastern United States. 1/

	Length of Route (miles) 2/	Miles of Pipeline			Shipping Lane (statute miles)	Traffic Problems (Tankers)		Ice Problems (Tankers)	Number of Ships (165,000 Cu.M. Capacity to Deliver 3.5 Bcf/day to California Port.)	Mileage Along Existing Roads	Miles of Permafrost		Number of Major Rivers Crossed	Miles Through Undeveloped Areas	Miles Through Cultivated Areas	Miles Through Tile Drainage	Number of Major Mountain Pass Crossings	Earthquake Potential (Magnitude) (Richter Scale)		Native Villages 3/		Miles Through Sensitive Wildlife Areas		
		Total	New	Existing	(Alaska Terminal to California Terminal)	Alaska Port	California Port	Alaskan Waters			Total	Ice-Rich						Alaska	California	Number	Population	Caribou Calving Grounds	Caribou Migration Routes	Waterfowl Habitat
Trans-Alaska Pipeline to Gravina Point Terminal and LNG Tankers to U.S. Markets via:																								
Pt. Conception, CA (Route via Arvin, CA)	6704	4652	1747	2905	2185	Mod. to High (Both oil & gas super tankers)	Low	Moderate (Columbia Glacier) icebergs)	12	1143	780	380	34	137	184	30	10	High (South end 8.4)	High (So. CA 6.0 - 8.2)	5	567	None	110	120
Oxnard, CA (Route via Hinckley, CA)	6685	4437	1532	2905	2260	Mod. to High (Both oil & gas super tankers)	Low	Moderate (Columbia Glacier icebergs)	12	986	780	380	31	100	169	30	5	High (South end 8.4)	Moderate (Oxnard thru San Andreas Fault 5.5)	5	567	None	110	120
Los Angeles, CA (Route via Yorba, CA)	6344	4024	1399	2625	2320	Mod. to High (Both oil & gas super tankers)	High	Moderate (Columbia Glacier icebergs)	12	1156	780	380	31	169	110	30	2	High (South end 8.4)	High (Fault at L.A. 8.2)	5	567	None	110	120
Trans-Alaska Pipeline to Cook Inlet Terminal and LNG Tankers to U.S. Markets via:																								
Pt. Conception, CA (Route via Arvin, CA)	6917	4692	1787	2905	2358	Moderate	Low	Moderate (broken ice north of the Forelands)	13	1228	640	300	40	91	194	30	10	High (South end 8.4)	High (So. CA 6.0 - 8.2)	4	275	None	105	170
Oxnard, CA (Route via Hinckley, CA)	6898	4477	1572	2905	2433	Moderate	Low	Moderate (broken ice north of the Forelands)	13	1071	640	300	37	54	179	30	5	High (South end 8.4)	Moderate (Oxnard thru San Andreas Fault, 5.5)	4	275	None	105	170
Los Angeles, CA (Route via Yorba, CA)	6557	4064	1439	2625	2493	Moderate	High	Moderate (broken ice north of the Forelands)	13	1241	640	300	37	54	120	30	2	High (South end 8.4)	High (Fault at L.A., 8.2)	4	275	None	105	170
Trans-Alaska Pipeline to Haines Terminal and LNG Tankers to U.S. Markets via:																								
Pt. Conception, CA (Route via Arvin, CA)	6724	4902	1997	2905	1955	Moderate	Low	None	11	1438	860	450	32	91	234	30	10	High (South end 8.4)	High (So. CA 6.0 - 8.2)	8	653	None	90	155
Oxnard, CA (Route via Hinckley, CA)	6705	4687	1782	2905	2030	Moderate	Low	None	11	1281	860	450	29	54	219	30	5	High (South end 8.4)	Moderate (Oxnard thru San Andreas Fault, 5.5)	8	653	None	90	155
Los Angeles, CA (Route via Yorba, CA)	6363	4274	1649	2625	2090	Moderate	High	None	11	1451	860	450	29	54	160	30	2	High (South end 8.4)	High (Fault at L.A., 8.2)	8	653	None	90	155
Trans-Alaska Pipeline to Golovin Terminal and LNG Tankers to U.S. Markets via:																								
Pt. Conception, CA (Route via Arvin, CA)	7909	4592	1687	2905	3450	Low	Low	Severe (up to 736 miles of ice for nine months of year)	18	438	750	380	23	781	174	30	9	Slight	High (So. CA 6.0 - 8.2)	8	914	None	90	155
Oxnard, CA (Route via Hinckley, CA)	7890	4377	1472	2905	3525	Low	Low	Severe (up to 736 miles of ice for nine months of year)	18	281	750	380	20	744	159	30	4	Slight	Moderate (Oxnard thru San Andreas Fault, 5.5)	8	914	None	140	120
Los Angeles, CA (Route via Yorba, CA)	7549	3964	1339	2625	3585	Low	High	Severe (up to 736 miles of ice for nine months of year)	18	451	750	380	20	744	100	30	1	Slight	High (Fault at L.A., 8.2)	8	914	None	140	120

1/ All mileages are given in statute miles.

2/ Length of route includes actual mileage of new pipeline in Alaska, actual distance of marine route from Alaska port to California port, actual distance from the California port through a combination of new and existing pipelines to a point in Texas and straight line distances from this point to markets in northcentral and northeastern U.S.

3/ Only those villages within 50 miles of the corridor and with 50% or more native population were included.

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